U.S. Army
Coast. Eng. Res. Ctr.

CETA 82-1

Hand-Held Calculator Algorithms for Coastal Engineering

by

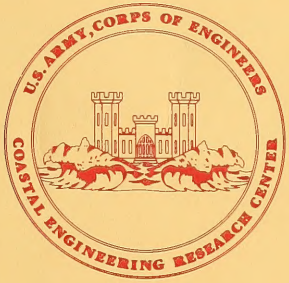
Todd L. Walton, Jr., William A. Birkemeier,

and J. Richard Weggel

COASTAL ENGINEERING TECHNICAL AID NO. 82-1

JANUARY 1982

WHOI
DOCUMENT
COLLECTION



Approved for public release;
distribution unlimited.

U.S. ARMY, CORPS OF ENGINEERS
COASTAL ENGINEERING
RESEARCH CENTER
Kingman Building
Fort Belvoir, Va. 22060

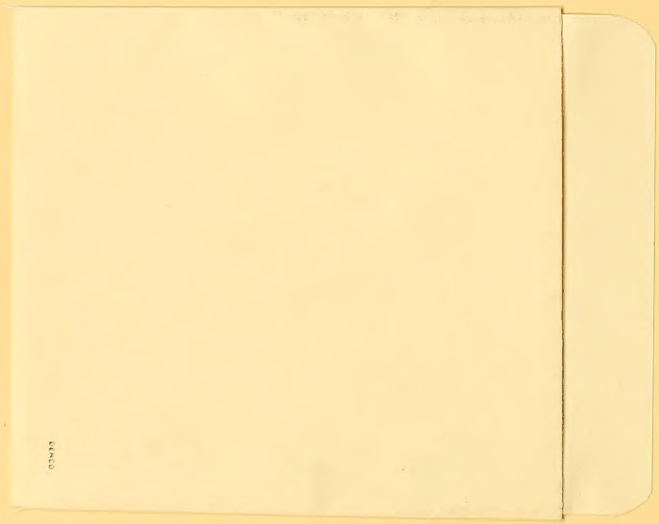
TC
330
.U8
no 82-1

Reprint or republication of any of this material shall give appropriate credit to the U.S. Army Coastal Engineering Research Center.

Limited free distribution within the United States of single copies of this publication has been made by this Center. Additional copies are available from:

National Technical Information Service
ATTN: Operations Division
5285 Port Royal Road
Springfield, Virginia 22161

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.





UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: CETA 82-1
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: HAND-HELD CALCULATOR ALGORITHMS FOR COASTAL ENGINEERING

5. TYPE OF REPORT & PERIOD COVERED: Coastal Engineering Technical Aid

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Department of the Army
Coastal Engineering Research Center (CEREN-EV)
Kingman Building, Fort Belvoir, Virginia 22060

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: C31181

11. CONTROLLING OFFICE NAME AND ADDRESS: Department of the Army
Coastal Engineering Research Center
Kingman Building, Fort Belvoir, Virginia 22060

12. REPORT DATE: January 1982

13. NUMBER OF PAGES: 71

14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*:

15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Calculator algorithms
Coastal engineering
Wave generation
Wave transformations

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included with different versions for use with hand-held calculators which employ either the Reverse Polish Notation (RPN) or the Algebraic Operating System (AOS). These programs can be used to compute linear wave parameters, orbital velocities, breaking wave height and direction, shallow-water wave forecasts, depth-limited breaking wave height, and wave transmission past a vertical barrier.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

PREFACE

This report provides coastal engineers algorithms for a number of hand-held calculator programs for coastal engineering, primarily in the area of wave transformations and wave generation. These algorithms were developed under the coastal engineering research program of the U.S. Army Coastal Engineering Research Center (CERC).

The report was written by Dr. Todd L. Walton, Jr., Hydraulic Engineer; William A. Birkemeier, Hydraulic Engineer; and Dr. J. Richard Weggel, Chief, Evaluation Branch, Engineering Development Division.

The authors acknowledge the assistance of A. Fromer and K. Stacy in preparing the manuscript. Reviews by R.A. Jachowski and Dr. R.J. Hallermeier of CERC and Dr. G. Oertel of Old Dominion University were appreciated.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

CONTENTS

		Page
	CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI)	5
I	INTRODUCTION	7
II	PROGRAMS	7
	1. 100R Linear Wave Theory Wavelength (RPN logic)	9
	100A Linear Wave Theory Wavelength (RPN logic)	12
	2. 101R Calculation of Wave Parameters from Linear Theory (RPN logic)	16
	101A Calculation of Wave Parameters from Linear Theory (AOS logic)	21
	3. 102R Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle (RPN logic)	29
	102A Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle (AOS logic)	34
	4. 103R Shallow-Water Wave Forecasting Equations (RPN logic)	41
	103A Shallow-Water Wave Forecasting Equations (AOS logic)	45
	5. 104R Depth-Limited Design Breaking Wave Height at Structure (RPN logic)	50
	104A Depth-Limited Design Breaking Wave Height at Structure (AOS logic)	54
	6. 105R Wave Transmission - Fuchs' Equation (RPN logic)	58
	105A Wave Transmission - Fuchs' Equation (AOS logic)	61
APPENDIX	BLANK PROGRAM FORMS	67

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

HAND-HELD CALCULATOR ALGORITHMS FOR COASTAL ENGINEERING

by
Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel

I. INTRODUCTION

The advent of the hand-held programable calculator has led to the development of numerous programs in various fields of engineering and science. Coastal engineering is no exception. This report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation.

There are basically two types of hand-held programable calculators: those that use algebraic logic, such as Texas Instruments, Algebraic Operating System (AOS) notation, and those that use Reverse Polish Notation (RPN), such as Hewlett-Packard. For the six programs presented herein, versions in each type of notation are provided--AOS designated by "A" and RPN designated by "R." Each program is documented, the assumptions are briefly described, and references to more detailed presentations of the theory are given.

Since subtle differences exist among various brands of calculators and among various models by the same manufacturer, the programs presented may need to be modified to adapt them to other brands or models. These programs were prepared and checked, using the Texas Instruments TI-59 (AOS) and the Hewlett-Packard HP67 (RPN). Users should refer to the operating manuals supplied with individual calculators. Algorithms may be set up specifically to meet some limiting conditions. For example, some programable calculators have a limiting restriction on the number of program steps accepted so a program must be revised to meet the limitation. The Texas Instruments TI-57, for example, accepts only 50 program steps. Algorithms may be adapted to meet this limitation by requiring prior calculation of input parameters either manually or by another program.

Each of the AOS programs incorporates TI-59 compatible print routines which print and label all input and output parameters. The user only has to enter the input parameters and the results are automatically computed and printed. Since the printing routines increase program length by as much as 25 percent, use of a magnetic card for permanent program storage is recommended. All print steps are marked with asterisks and need not be entered if printing is not desired.

II. PROGRAMS

Six programs (100, 101, 102, 103, 104, and 105) are presented in this report. Program 100, a simple program that computes linear wave theory wavelength for a given depth, is designed to be used as the basis for any program that requires wavelength; in fact, it has been incorporated into programs 101, 102, and 105.

Program 101 is another basic program which computes not only wavelength but also a number of other linear wave theory parameters. This program forms the basis for program 102 and can be adapted to other programs as well.

Program 102 computes linear wave parameters and breaking wave height and direction based on nearshore or deepwater wave information. Program 103 can be used to forecast wave height and period in shallow water. Program 104 and 105 address wave conditions at structures--program 104 predicts the depth-limited design breaking wave height at a structure; 105 uses Fuch's equation to predict wave transmission over a thin barrier.

Each program allows either English or metric input and output (the AOS programs print an "M" when metric is selected). Program listings are annotated, making it possible to follow the logic of the algorithm and to make modifications if desired.

There are undoubtedly many calculator programs not included here that have been developed on coastal engineering subjects. Practicing engineers who would like to disseminate such programs (in either AOS or RPN) to other users are encouraged to submit them to the Coastal Engineering Research Center (CERC). If the response is great enough, additional reports presenting the programs will be prepared. Comments, programs, or suggestions for programs should be sent to:

Commander and Director
US Army Coastal Engineering Research Center
ATTN: Evaluation Branch
Kingman Building
Fort Belvoir, VA 22060

These programs and future programs will generally correspond to the following numbering scheme:

Miscellaneous	0-99
Waves and currents	100-299
Inlets	300-499
Beaches	500-699
Geology	700-899
Structures	900-1099

In general, the documentation of programs submitted should be in a format paralleling that of the programs presented in this report. A blank set of forms which can be reproduced is included in the Appendix.

Program Description

Program Title	100R Linear Wave Theory Wavelength (RPN logic)				
Name	J.R. Weggel			**Date**	12/80
Address	Coastal Engineering Research Center				
City	Kingman Building Fort Belvoir,	**State**	Virginia	**Zip Code**	22060

Program Description, Equations, Variables, etc.

This algorithm takes deepwater wavelength as input and using the depth at a given site iterates to obtain wavelength by linear wave theory. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Eq. (2-4), Stock No. 008-002-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

User Instructions

Program Title: 100R Linear Wave Theory Wavelength (RPN logic)

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	TO COMPUTE WAVELENGTH IN FEET			
1	ENTER WAVE PERIOD T (SEC)	T(SEC)	A	T(SEC)
2	READ L_o (FT)			L_o(FT)
3	ENTER DEPTH d (FT)	d (FT)	C	d(FT)
4	READ L (FT)			L(FT)
	FOR NEW DEPTH GO TO STEP 3			
	TO COMPUTE WAVELENGTH IN METERS			
1	ENTER WAVE PERIOD T (SEC)	T(SEC)	f a	T(SEC)
2	READ L_o (M)			L_o(M)
3	ENTER DEPTH d (M)	d(M)	C	d(M)
4	READ L (M)			L(M)
	FOR NEW DEPTH GO TO STEP 3			
	EXAMPLE:			
	COMPUTE WAVE LENGTH OF 10 SECOND			
	WAVE IN 10 FEET OF WATER.			
	ENTER T = 10 SEC, PRESS A	10(SEC)	A	
	READ L_o = 512.48 (FT)			512.48
	ENTER DEPTH d = 10 (FT)	10(FT)	C	
	READ L = 175.77 (FT)			175.77

100R-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	ENTER T
	STO 7	33 07	T → R7
	3	03	
	2	02	
	.	83	
	2	02	
	STO 6	33 06	g (ENGLISH) → R6
	f LBL B	31 25 12	
	RCL 7	34 07	
010	g x^2	32 54	
	RCL 6	34 06	
	x	71	
	2	02	
	÷	81	
	h π	35 73	
	÷	81	
	STO 1	33 01	L_o → R1
	R/S	84	
	f LBL C	31 25 13	
020	2	02	
	x	71	
	h π	35 73	
	x	71	
	STO 5	33 05	2πd → R5
	RCL 1	34 01	
	f LBL D	31 25 14	
	STO 3	33 03	
	h y^x	35 62	
	RCL 5	34 05	
030	x	71	
	STO 4	33 04	$\frac{2\pi d}{L_{OLD}}$ → R4
	g e^x	32 52	
	RCL 4	34 04	
	CHS	42	
	g e^x	32 52	
	−	51	
	RCL 4	34 04	
	g e^x	32 52	
	RCL 4	34 04	
040	CHS	42	
	g e^x	32 52	
	+	61	tANh $\frac{2\pi d}{L_{OLD}}$
	÷	81	
	RCL 1	34 01	
	x	71	
	RCL 3	34 03	
	+	61	
	2	02	
	÷	81	
050	STO 2	33 02	
	RCL 3	34 03	
	−	51	
	h ABS	35 64	
	1	01	
	g x>y	32 81	
	GTO E	22 15	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	RCL 2.	34 02	
	GTO D	22 14	
	f LBL E	31 25 15	
060	RCL 2.	34 02	
	R/S	84	
	g LBL f a	32 25 11	PORTION OF PROGRAM NEEDED FOR METRIC
	STO 7	33 07	
	9	09	
	.	83	
	8	08	
	1	01	
	STO 6	33 06	
	GTO B	22 12	
070			
080			
090			
100			
110			

100R-3

Program Description

Program Title	100A Linear Wave Theory Wavelength (AOS logic)				
Name	J.R. Weggel			Date	12/80
Address	Coastal Engineering Research Center				
City	Kingman Building Fort Belvoir,	State	Virginia	Zip Code	22060

Program Description, Equations, Variables, etc.

This algorithm takes deepwater wavelength as input and using the depth at a given site iterates to obtain wavelength by linear wave theory. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Eq. (2-4), Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

User Instructions

Program Title: 100A Linear Wave Theory Wavelength (AOS logic)

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	TO COMPUTE WAVELENGTH			
1	ENTER WAVE PERIOD T (SEC)	T (SEC)	A	L_o (ft)
	PRESS A FOR ENGLISH UNITS	OR		
	OR PRESS A' FOR METRIC UNITS	T (SEC)	2nd A'	L_o (m)
2	READ L_o (ft or m)			
3	ENTER DEPTH d (ft or m)	d (ft or m)	B	L (ft or m)
4	READ L (ft or m)			
	TO REPEAT FOR NEW DEPTH GO TO STEP 3			
	EXAMPLE:			
	COMPUTE THE WAVELENGTH OF 10 SECOND WAVE IN			
	10 FEET OF WATER			
	ENTER T = 10 SEC PRESS A	10 SEC	A	
	READ L_o = 512.48 (ft)			512.48
	ENTER DEPTH d = 10 (Ft)	10 ft	B	
	READ L = 175.773 (ft)			175.773
	NOTE: COMPUTATION OF L REQUIRES ABOUT 16SEC			
	PRINTOUT OF EXAMPLE			
	10. T			
	512.4789168 LO			
	10. D			
	175.7737794 L			

100A-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
	000	76 LBL	
	001	11 A	
	002	42 STO	$T \rightarrow R_7$
	003	07 07	
	004	03 3	
	005	02 2	
	006	93 .	
	007	02 2	
	008	42 STO	$g_{ENGLISH} \rightarrow R_6$
	009	06 06	
	010	76 LBL	
	011	17 B'	
	012	03 3 *	"T" PRINT CODE
	013	07 7 *	
	014	69 OP *	
	015	04 04 *	
	016	43 RCL	
	017	07 07	
	018	69 OP *	PRINT T
	019	06 06 *	
	020	33 X^2	
	021	65 ×	
	022	43 RCL	$L_0 = gT^2/2\pi$
	023	06 06	
	024	55 ÷	
	025	02 2	
	026	55 ÷	
	027	89 π	
	028	95 =	
	029	42 STO	$L_0 \rightarrow R_{01}$
	030	01 01	
	031	02 2 *	
	032	07 7 *	"L_0" PRINT CODE
	033	03 3 *	
	034	02 2 *	
	035	69 OP *	
	036	04 04 *	
	037	43 RCL *	
	038	01 01 *	
	039	69 OP *	PRINT L_0
	040	06 06 *	
	041	91 R/S	
	042	76 LBL	ENTER d
	043	12 B	
	044	98 ADV *	
	045	32 X:T	
	046	01 1 *	
	047	06 6 *	"d" PRINT CODE
	048	69 OP *	
	049	04 04 *	
	050	01 1	
	051	32 X:T	
	052	69 OP *	PRINT d

STEP	KEY ENTRY	KEY CODE	COMMENTS
	053	06 06	
	054	65 ×	
	055	02 2	
	056	65 ×	
	057	89 π	
	058	95 =	
	059	42 STO	$2\pi d \rightarrow R_{00}$
	060	00 00	
	061	43 RCL	
	062	01 01	
	063	76 LBL	
	064	19 D'	
	065	42 STO	$L_{OLD} \rightarrow R_3$
	066	03 03	
	067	35 1/X	
	068	65 ×	
	069	43 RCL	
	070	00 00	
	071	95 =	
	072	42 STO	$2\pi d/L_{OLD} \rightarrow R_4$
	073	04 04	
	074	22 INV	
	075	23 LNX	
	076	75 -	
	077	48 EXC	
	078	04 04	
	079	94 +/-	
	080	22 INV	
	081	23 LNX	
	082	42 STO	
	083	05 05	
	084	95 =	
	085	55 ÷	
	086	53 (	
	087	43 RCL	
	088	04 04	
	089	85 +	
	090	43 RCL	
	091	05 05	
	092	95 =	$\tanh 2\pi d/L_{OLD}$
	093	65 ×	
	094	43 RCL	
	095	01 01	
	096	85 +	
	097	43 RCL	
	098	03 03	
	099	95 =	
	100	55 ÷	
	101	02 2	
	102	95 =	
	103	42 STO	$L_{NEW} \rightarrow R_2$
	104	02 02	
	105	75 -	
	106	43 RCL	

100A-3

* DELETE IF PRINTER IS NOT AVAILABLE

STEP	KEY ENTRY	KEY CODE	COMMENTS
	107	03 03	
	108	95 =	
	109	50 I×I	
	110	22 INV	
	111	77 GE	
	112	18 C'	
	113	43 RCL	
	114	02 02	
	115	19 D'	
	116	76 LBL	
	117	18 C'	
	118	02 2 *	"L" PRINT CODE
	119	07 7 *	
	120	69 OP *	
	121	04 04 *	
	122	43 RCL	
	123	02 02	
	124	69 OP *	PRINT L
	125	06 06 *	
	126	91 R/S	L IN DISPLAY
	127	76 LBL	ROUTINE TO PUT g=9.81 INTO R_6 FOR METRIC CALCULATIONS
	128	16 A'	
	129	42 STO	
	130	07 07	
	131	09 9	
	132	93 .	
	133	08 8	
	134	01 1	
	135	42 STO	
	136	06 06	
	137	03 3 *	DELETE IF ONLY ENGLISH UNITS ARE TO BE PROCESSED
	138	00 0 *	
	139	69 OP *	
	140	04 04 *	
	141	69 OP *	
	142	05 05 *	
	143	17 B'	
160			

STEP	KEY ENTRY	KEY CODE	COMMENTS
170			
180			
190			
200			
210			
220			

100A-4

Program Description

Program Title	101R Calculation of Wave Parameters from Linear Theory (RPN logic)			
Name	T.L. Walton, Jr.		Date	12/80
Address	Coastal Engineering Research Center			
City	Kingman Building Fort Belvoir,	State Virginia	Zip Code	22060

Program Description, Equations, Variables, etc.

This program calculates the product of the wave number and depth, kd, the ratio of group wave speed to wave celerity, $n = 0.5\ (1+2kd/\sinh 2kd)$, the group wave speed, Cg, the shoaling coefficient, K_s, the refraction coefficient, K_r, horizontal orbital velocity, u, and vertical orbital velocity, w.

Program input includes wave period, T, deepwater wave angle, α_o, deepwater wave height, H_o, wave phase angle, θ, depth of water, d, at which results are desired, and depth from surface, z, at which velocities are calculated. This program assumes straight and parallel offshore bottom contours for assumption of Snell's law of refraction. Algorithm uses English or metric system of units.

REFERENCES

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings This program can also be used for wave input H, T, and α, from transitional water depths (as in the case when wave gage information is provided but the gage is not in deep water). In this instance, some program steps must be deleted as noted in the program listing, and the K_r computed in the program is *not* the refraction coefficient for depth, d, but a *modified* refraction coefficient from the gage site to water depth, d.

User Instructions

Program Title: 101R Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	TO COMPUTE WAVE PARAMETERS			
	IF DESIRED TO CALCULATE ORBITAL			
	VELOCITIES U,W AT A SPECIFIED			
	PHASE ANGLE, "θ", INCLUDE			
	THE FOLLOWING STEPS:			
1	ENTER H_o (FT. OR M) IN DISPLAY *	H_o(FT OR M)		
2	PRESS STO B, STORING H IN R_B		STO 8	
3	ENTER Z (FT OR M) IN DISPLAY	Z(FT OR M)		
4	PRESS STO B, STORING Z IN R_B		STO B	
5	ENTER θ (DEGREES) IN DISPLAY	θ(DEGREES)		
6	PRESS STO E, STORING θ IN R_E		STO E	
	IF U AND W ARE NOT DESIRED the			
	FOREGOING STEPS CAN BE OMITTED			
7	ENTER WAVE PERIOD T (SEC)	T(SEC)	A	T
8	ENTER DEPTH d (METERS OR FT)	d(FT OR M)	B	$2\pi d$
9	ENTER DEEPWATER WAVE ANGLE			
	α_o (DEGREES)	α_o(DEG)	C	SIN α
10	PRESS E TO COMPUTE WAVE PARAMETERS		E	ENGLISH
	IN ENGLISH UNITS OR;			
	PRESS D FOR METRIC UNITS		D	METRIC
11	READ K d IN DISPLAY			Kd
12	PRESS R/S AND READ n		R/S	n
13	PRESS R/S AND READ C_g (FT OR M)		R/S	C_g(FT OR M)
14	PRESS R/S AND READ K_s		R/S	K_s
15	PRESS R/S AND READ K_r		R/S	K_r
16*	PRESS R/S AND READ H (FT OR M) *		R/S	H(FT OR M)
17	PRESS R/S AND READ U (FT/SEC OR M/SEC)		R/S	U(F/S OR M/S)
18	PRESS R/S AND READ W (FT/SEC OR M/SEC)		R/S	W(F/S OR M/S)
	SEE EXAMPLE, NEXT PAGE			
	* IF WAVE HEIGHT H AT DEPTH d			
	IS ENTERED, DELETE STEPS			
	WITH ASTERISK *.			

101R-2

User Instructions

Program Title: 101R Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	EXAMPLE			
	H_o = 18 FT, Z = -15 FT, Θ = 60°			
	T = 8 SEC, d = 50 FT, α_o = 30°			
	ENTER H_o = 18, PRESS STO 8	18	STO B	18.00
	ENTER Z = -15, PRESS STO B	-15	STO B	-15.00
	ENTER Θ = 60°, PRESS STO E	60	STO E	60.00
	ENTER T = 8 SEC., PRESS A		A	8.00
	ENTER d = 50 FT., PRESS B		B	314.00
	ENTER α_o = 30°, PRESS C		C	0.50
	PRESS E, READ Kd = 1.16		E	1.16
	PRESS R/S, READ n = 0.73		R/S	0.73
	PRESS R/S, READ C_g = 24.62 FT/SEC		R/S	24.62
	PRESS R/S, READ K_s = 0.91		R/S	0.91
	PRESS R/S, READ K_r = 0.97		R/S	0.97
	PRESS R/S, READ H = 16.01 FT. *		R/S	16.01
	PRESS R/S, READ U = 2.94 FT/SEC		R/S	2.94
	PRESS R/S, READ W = 3.43 FT/SEC		R/S	3.43

101R-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	
	STO 2	33 02	T → R_2
	RIS	84	
	f LBL B	31 25 12	
	h π	35 73	
	X	71	
	2	02	
	X	71	
	STO 1	33 01	2π d → R_1
010	RIS	84	
	f LBL C	31 25 13	
	f SIN	31 62	
	STO 0	33 00	SIN α_o → R_0
	RIS	84	
	f LBL D	31 25 14	
	9	09	
	•	83	
	8	08	
	1	01	
020	STO D	33 14	g(METRIC) → R_D
	f GSB 0	31 22 00	
	GTO f a	22 31 11	
	f LBL E	31 25 15	
	3	03	
	2	02	
	•	83	
	2	02	
	STO D	33 14	g(ENGLISH) → R_D
	f GSB 0	31 22 00	
030	g LBL f a	32 25 11	
	2	02	
	X	71	
	STO A	33 11	$\frac{4\pi d}{L}$ → R_A
	f GSB 1	31 22 01	
	h 1/x	35 62	
	RCL A	34 11	
	X	71	
	1	01	
	+	61	
040	2	02	
	÷	81	
	STO A	33 11	n → R_A
	RIS	84	n IN DISPLAY
	RCL 4	34 04	
	X	71	
	RCL 2	34 02	
	=	81	
	RIS	84	Cg IN DISPLAY
	h Y_x	35 62	
050	RCL 2	34 02	
	X	71	
	RCL D	34 14	
	X	71	
	4	04	
	=	81	
	h π	35 73	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	=	81	
	f $\sqrt{x}$	31 54	
	STO A	33 11	$K_S = \sqrt{C_{go}/C_g}$ → R_A
060	RIS	84	K_S IN DISPLAY
	RCL 0	34 00	
	RCL 1	34 01	
	X	71	
	RCL 3	34 03	
	÷	81	Kod SIN α_o
	RCL 9	34 09	
	÷	81	SIN α
	g x^2	32 54	
	1	01	
070	−	51	
	CHS	42	$COS^2 \alpha$
	h Y_x	35 62	
	1	01	
	ENTER	41	
	RCL 0	34 00	
	g x^2	32 54	
	=	51	
	X	71	
	f $\sqrt{x}$	31 54	
080	f $\sqrt{x}$	31 54	
	h STI	35 33	K_R → R_1
	RIS	84	K_R IN DISPLAY
	g LBL f b	32 25 12	
	RCL B	34 08	
	h RCI *	35 34	
	X *	71	
	RCL A *	34 11	
	X *	71	
	RIS *	84	
090	RCL D	34 14	
	X	71	
	RCL 2	34 02	
	X	71	
	2	02	
	÷	81	
	RCL 4	34 04	
	=	81	
	RCL 6	34 06	
	÷	81	$\frac{H}{2} \frac{gT}{L} \frac{1}{\cosh \frac{2\pi d}{L}}$
100	STO 8	33 08	→ R_B
	RCL 1	34 01	
	2	02	
	÷	81	
	h π	35 73	
	÷	81	
	RCL B	34 12	
	+	61	
	2	02	
	X	71	
110	h $\sqrt{\pi}$	35 73	
	X	71	
	RCL 4	34 04	

101R-4

DELETE THESE STEPS IF ENTERED WAVE HEIGHT IS AT DEPTH d

STEP	KEY ENTRY	KEY CODE	COMMENTS
	÷	81	$\frac{2\pi(z+d)}{L} \rightarrow R_5$
	STO 5	33 05	
	f GSB 2	31 22 02	
	RCL B	34 0B	
	x	71	
	RCL E	34 15	
	f COS	31 63	
120	x	71	
	RIS	84	U IN DISPLAY
	RCL 5	34 05	
	f GSB 1	31 22 01	
	RCL 8	34 08	
	x	71	
	RCL E	34 15	
	f SIN	31 62	
	x	71	
	RIS	84	W IN DISPLAY
130	f LBL 0	31 25 00	SUB TO CALC. L
	RCL 2	34 02	
	g x^2	32 54	
	RCL D	34 14	
	x	71	
	2	02	
	÷	81	
	h π	35 73	
	÷	81	
	STO 3	33 03	$L_O \rightarrow R_3$
140	g LBL d	32 25 14	
	STO A	33 11	$L_{OLO} \rightarrow R_A$
	h y^x	35 62	
	RCL 1	34 01	
	x	71	
	STO C	33 13	$\frac{2\pi d}{L_{OLO}} \rightarrow R_C$
	f GSB 2	31 22 02	
	STO 6	33 06	$\cosh\left(\frac{2\pi d}{L_{OLO}}\right) \rightarrow R_6$
	RCL C	34 13	
	f GSB 1	31 22 01	
150	STO 5	33 05	$\sinh\left(\frac{2\pi d}{L_{OLO}}\right) \rightarrow R_5$
	RCL 6	34 06	
	÷	81	
	RCL 3	34 03	
	x	71	
	RCL A	34 11	
	÷	61	
	2	02	
	÷	81	
	STO 4	33 04	$L_{NEW} \rightarrow R_4$
160	RCL A	34 11	
	−	51	
	h ABS	35 64	
	1	01	
	g x≥y	32 81	
	GTO e	22 31 15	
	RCL 4	34 04	
	GTO d	22 31 19	
	f LBL e	32 25 15	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	RCL 1	34 01	
170	RCL 4	34 04	
	÷	81	
	STO 9	33 09	$K_d \rightarrow R_9$
	RIS	84	
	h RTN	35 22	SUB sinh ()
	f LBL 1	31 25 01	
	STO 7	33 07	
	g e^x	32 52	
	RCL 7	34 07	
	CHS	42	
180	g e^x	32 52	
	−	51	
	2	02	
	÷	81	
	h RTN	35 22	
	f LBL 2	31 25 02	
	STO 7	33 07	
	g e^x	32 52	
	RCL 7	34 07	
	CHS	42	
190	g e^x	32 52	
	+	61	
	2	02	
	÷	81	
	h RTN	35 22	SUB cosh ()
200			
210			
220			

101R-5

Program Description

Program Title	101A Calculation of Wave Parameters from Linear Theory (AOS logic)
Name	W.A. Birkemeier **Date** 5/81
Address	CERC Field Research Facility
City	Kitty Hawk, **State** North Carolina **Zip Code** 27949

Program Description, Equations, Variables, etc.

This program calculates the product of the wave number and depth, k_d, the ratio of group wave speed to wave celerity, $n = 0.5\ (1+2kd/\sinh 2kd)$, the group wave speed, C_g, the shoaling coefficient, K_s, the refraction coefficient, K_r, horizontal orbital velocity, u, and vertical orbital velocity, w.

Program input includes wave period, T, deepwater wave angle, α_o, deepwater wave height, H_o, wave phase angle, θ, depth of water, d, at which results are desired, and depth from surface, z, at which velocities are calculated. This program assumes straight and parallel offshore bottom contours for assumption of Snell's law of refraction. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings This program can also be used for wave input H, T, and α, from transitional water depths (as in the case when wave gage information is provided but the gage is not in deep water). In this instance, some program steps must be deleted as noted in the program listing, and the K_r computed in the program is *not* the refraction coefficient for depth, d, but a *modified* refraction coefficient from the gage site to water depth, d.

User Instructions

Program Title: 101A Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
	TO COMPUTE WAVE PARAMETERS				
1	ENTER WAVE PERIOD T(SEC)	T (SEC)	A		T
2	ENTER DEPTH d (ft OR m)	d	B		2nd
3	ENTER DEEPWATER WAVE ANGLE	α_o (deg)	C		$\sin \alpha_o$
4	PRESS E to COMPUTE WAVE		E		
	PARAMETERS (ENGLISH UNITS) OR PRESS D FOR		D		
	METRIC UNITS				
	NOTE: WITH A PRINTER Kd, n, Cg, Ks,	Kr			
	ARE PRINTED AND LABELED IN ABOUT 20 SEC,				
	OTHERWISE:				
5	READ Kd IN DISPLAY				Kd
6	PRESS R/S AND READ n		R/S		n
7	PRESS R/S AND READ Cg (ft/SEC OR M/SEC)		R/S		Cg
8	PRESS R/S AND READ Ks		R/S		Ks
9	PRESS R/S AND READ Kr		R/S		Kr
	TO REPEAT, ENTER NEW VALUE USING STEPS 1, 2, OR 3				
	AND STEP 4				
	TO COMPUTE WAVE ORBITAL VELOCITY, AFTER COMPLETING				
	THE ABOVE STEPS.				
A	ENTER DEEPWATER WAVE HEIGHT H_o (ft OR m) PRESS A'	H_o	2nd	A'	
	NOTE: IF H, NOT H_o IS KNOWN, DELETE PROGRAM				
	STEPS MARKED BY •.				
	THEN ENTER H INSTEAD OF H_o.				
B	ENTER DEPTH BELOW STILL WATER	Z	2nd	B'	
	(NEGATIVE ft OR M)				
C	COMPUTE AND ENTER THE PHASE ANGLE				
	$\Theta = \left(\frac{2\pi x}{L} - \frac{2\pi t}{L}\right)$ IN DEGREES	Θ (DEG)	2nd	C'	

101A-2

User Instructions

Program Title: 101A Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	WITH PRINTER H, U, AND W ARE PRINTED IN			
	APPROPRIATE UNITS (VELOCITIES ARE IN ft/sec			
	OR M/SEC) OTHERWISE:			
D	READ H IN DISPLAY (IF USING H NOT H_o,			H
	READ U IN DISPLAY AND PROCEED TO STEP F)			
E	PRESS R/S AND READ U IN DISPLAY		R/S	U
F	PRESS R/S AND READ W IN DISPLAY		R/S	W
	TO REPEAT, START AT STEP C FOR NEW θ OR			
	WITH STEP A OR B AND THEN C.			

101A-3

User Instructions

Program Title: 101A Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	EXAMPLE : CALCULATE WAVE PARAMETERS FOR :			
	$T = 8$ SEC			
	$d = 50$ ft			
	$\alpha_0 = 30°$			
	$H_0 = 18$ ft			
	$Z = -15$ ft			
	$\theta = 60°$			
	ENTER T PRESS A	8 SEC	A	8
	ENTER d PRESS B	50 ft	B	314.15
	ENTER α_0 PRESS C	30°	C	0.5
	PRESS E TO COMPUTE		E	
	CALCULATED VALUES ARE PRINTED OR			
	READ $K_d = 1.163$			1.163
	PRESS R/S AND READ $n = 0.729$			0.729
	PRESS R/S AND READ $C_g = 24.625$ ft/sec			24.625
	PRESS R/S AND READ $K_s = 0.912$			0.912
	PRESS R/S AND READ $K_r = 0.975$			0.954
	ENTER H_0 PRESS A'	18 ft	2nd A'	223.65
	ENTER Z PRESS B'	-15 ft	2nd B'	-94.25
	ENTER θ PRESS C'	60°	2nd C'	
	CALCULATED VALUES ARE PRINTED OR:			
	READ $H = 16.0$ ft, PRESS R/S AND READ $U = 2.944$ ft/sec			2.944
	PRESS R/S AND READ $W = 3.426$ ft/sec			3.426

EXAMPLE PRINTOUT

```
      8.          T
     50.          D
     30.          ANGO

 1.16314388       KD
 0.729367164      N
 24.62479667      CG
 .9123924245      KS
 .9748438618      KR

     18.          HO
    -15.          Z
     60.          PANG
 16.00992278      H
 2.943703553      U
 3.42578442       W
```

101A-4

Program Listing

STEP	KEY ENTRY	KEY CODE		COMMENTS
000	76	LBL		
001	11	A		
002	42	STO		$T \rightarrow R_2$
003	02	02		
004	03	3	*	
005	07	7	*	"T" PRINT CODE
006	69	OP	*	
007	04	04	*	
008	43	RCL	*	
009	02	02	*	
010	69	OP	*	PRINT T
011	06	06	*	
012	91	R/S		
013	76	LBL		
014	12	B		
015	42	STO		$d \rightarrow R_1$
016	01	01		
017	01	1	*	"D" PRINT CODE
018	06	6	*	
019	69	OP	*	
020	04	04	*	
021	43	RCL	*	
022	01	01	*	
023	69	OP	*	
024	06	06	*	PRINT d
025	65	×		
026	89	π		
027	65	×		
028	02	2		
029	95	=		
030	42	STO		$2\pi d \rightarrow R_{11}$
031	11	11		$2\pi d$ IN DISPLAY
032	91	R/S		
033	76	LBL		
034	13	C		
035	42	STO		$\alpha_0 \rightarrow R_0$
036	00	00		
037	01	1	*	
038	03	3	*	
039	03	3	*	"ANGO" PRINT CODE
040	01	1	*	
041	02	2	*	
042	02	2	*	
043	00	0	*	
044	01	1	*	
045	69	OP	*	
046	04	04	*	
047	43	RCL	*	
048	00	00	*	
049	69	OP	*	PRINT α_0
050	06	06	*	
051	38	SIN		
052	42	STO		$\sin \alpha_0 \rightarrow R_0$
053	00	00		
054	91	R/S		$\sin \alpha_0$ IN DISPLAY
055	76	LBL		
056	38	SIN		SUBROUTINE TO COMPUTE $\sin h(x)$
057	42	STO		
058	07	07		
059	22	INV		
060	23	LNX		
061	75	-		
062	43	RCL		
063	07	07		
064	94	+/-		
065	22	INV		
066	23	LNX		
067	95	=		
068	55	÷		
069	02	2		
070	95	=		
071	92	RTN		
072	76	LBL		
073	39	COS		SUBROUTINE TO COMPUTE $\cos h(x)$
074	42	STO		
075	07	07		
076	22	INV		
077	23	LNX		
078	85	+		
079	43	RCL		
080	07	07		
081	94	+/-		
082	22	INV		
083	23	LNX		
084	95	=		
085	55	÷		
086	02	2		
087	95	=		
088	92	RTN		
089	76	LBL		ROUTINE TO ALLOW METRIC INPUT/OUTPUT
090	14	D		
091	09	9		
092	93	.		
093	08	8		
094	01	1		
095	42	STO		
096	13	13		DELETE IF UNWANTED
097	03	3	*	
098	00	0	*	
099	69	OP	*	$g = 9.81 \rightarrow R_{13}$
100	04	04	*	
101	69	OP	*	
102	05	05	*	ROUTINE PRINTS AN "M" TO INDICATE METRIC
103	61	GTO		
104	43	RCL		
105	76	LBL		
106	15	E		
107	03	3		

101A-5

* - DELETE IF PRINTER IS NOT AVAILABLE

STEP	KEY ENTRY	KEY CODE	COMMENTS
108	02	2	$g = 32.2 ft/sec^2$
109	93	.	
110	02	2	
111	42	STO	
112	13	13	$\rightarrow R_{13}$
113	76	LBL	
114	43	RCL	
115	98	ADV	
116	01	1	
117	32	X:T	
118	43	RCL	$1 \rightarrow t$ register
119	02	02	
120	33	X^2	
121	65	×	
122	43	RCL	
123	13	13	
124	55	÷	$L_0 = gT^2/2\pi$
125	02	2	
126	55	÷	
127	89	π	
128	95	=	
129	42	STO	$L_0 \rightarrow R_3$
130	03	03	
131	76	LBL	
132	19	D'	
133	42	STO	$L_{OLD} \rightarrow R_{10}$
134	10	10	
135	35	1/X	
136	65	×	
137	43	RCL	
138	11	11	
139	95	=	$\frac{2\pi d}{L_{OLD}} \rightarrow R_{12}$
140	42	STO	
141	12	12	
142	71	SBR	
143	39	COS	$\cosh\left(\frac{2\pi d}{L_{OLD}}\right) \rightarrow R_6$
144	42	STO	
145	06	06	
146	43	RCL	
147	12	12	
148	71	SBR	
149	38	SIN	
150	42	STO	$\sinh\left(\frac{2\pi d}{L_{OLD}}\right) \rightarrow R_5$
151	05	05	
152	55	÷	
153	43	RCL	
154	06	06	
155	65	×	
156	43	RCL	
157	03	03	
158	85	+	
159	43	RCL	
160	10	10	
161	95	=	
162	55	÷	
163	02	2	
164	95	=	
165	42	STO	
166	04	04	$L_{NEW} \rightarrow R_4$
167	75	-	
168	43	RCL	
169	10	10	
170	95	=	
171	50	I×I	ITERATE UNTIL
172	22	INV	$L_{NEW} - L_{OLD} < t$
173	77	GE	WHERE t IS VALUE
174	10	E'	IN t REGISTER
175	43	RCL	
176	04	04	
177	19	D'	
178	76	LBL	
179	10	E'	
180	43	RCL	
181	11	11	
182	55	÷	
183	43	RCL	
184	04	04	
185	95	=	
186	42	STO	$\frac{2\pi d}{L} = kd \rightarrow R_9$
187	09	09	
188	02	2	*
189	06	6	* "KD" PRINT CODE
190	01	1	*
191	06	6	*
192	69	OP	*
193	04	04	*
194	43	RCL	*
195	09	09	*
196	69	OP	* PRINT Kd
197	06	06	*
R/S → SEE BELOW 198	65	×	
199	02	2	
200	95	=	
201	42	STO	
202	10	10	
203	71	SBR	
204	38	SIN	
205	35	1/X	
206	65	×	
207	43	RCL	
208	10	10	
209	85	+	
210	01	1	
211	95	=	
212	55	÷	
213	03	3	* "N" PRINT CODE
214	01	1	*
215	69	OP	*

101A-6

*-DELETE IF PRINTER IS NOT AVAILABLE
R/S- INSERT IF PRINTER IS NOT AVAILABLE

STEP	KEY ENTRY	KEY CODE		COMMENTS
	216	04	4 *	
	217	02	2	
	218	95	=	
	219	42	STO	$n \rightarrow R_{10}$
	220	10	10	
	221	69	OP	PRINT n
	222	06	06	
	223	65	×	
	224	01	1 *	
	225	05	5 *	"CG" PRINT CODE
	226	02	2 *	
	227	02	2 *	
	228	69	OP *	
	229	04	04 *	
	230	43	RCL	
	231	04	04	
	232	55	÷	
	233	43	RCL	
	234	02	02	
	235	95	=	
	236	69	OP *	PRINT C_g
R/S →	237	06	06 *	
	238	35	1/X	
	239	65	×	
	240	02	2 *	
	241	06	6 *	"K_s" PRINT CODE
	242	03	3 *	
	243	06	6 *	
	244	69	OP *	
	245	04	04 *	
	246	43	RCL	
	247	02	02	
	248	65	×	
	249	43	RCL	
	250	13	13	
	251	55	÷	
	252	04	4	
	253	55	÷	
	254	89	π	
	255	95	=	
	256	34	FX	
	257	42	STO	$K_s = \sqrt{C_{g_0}/C_g} \rightarrow R_{10}$
	258	10	10	
	259	69	OP *	
	260	06	06 *	PRINT K_s
	261	02	2 *	
	262	06	6 *	"KR" PRINT CODE
	263	03	3 *	
	264	05	5 *	
	265	69	OP *	
	266	04	04 *	
	267	43	RCL	
	268	00	00	
	269	65	×	
	270	43	RCL	

STEP	KEY ENTRY	KEY CODE		COMMENTS
	271	11	11	
	272	55	÷	
	273	43	RCL	
	274	03	03	
	275	55	÷	
	276	43	RCL	
	277	09	09	
	278	95	=	
	279	33	X^2	
	280	75	-	
	281	01	1	
	282	95	=	
	283	94	+/-	$\cos^2\alpha$
	284	35	1/X	
	285	65	×	
	286	53	(	
	287	01	1	
	288	75	-	
	289	43	RCL	
	290	00	00	
	291	33	X^2	
	292	95	=	
	293	34	FX	
	294	34	FX	
•	295	42	STO	
•	296	01	01	
	297	69	OP *	PRINT K_r
	298	06	06 *	
	299	98	ADV	
	300	91	R/S	
	301	76	LBL	REMAINING STEPS REQUIRED IF ORBITAL VELOCITIES ARE DESIRED
	302	16	A'	
	303	42	STO	
	304	08	08	
	305	02	2 *	$H_0 \rightarrow R_8$
	306	03	3 *	"H0" PRINT CODE
•	307	00	0 *	
•	308	01	1 *	
	309	69	OP *	
	310	04	04 *	
	311	43	RCL *	
	312	08	08 *	
•	313	65	×	
	314	69	OP *	PRINT H_0
	315	06	06 *	
•	316	43	RCL	
•	317	10	10	
•	318	65	×	
•	319	43	RCL	
•	320	01	01	
•	321	95	=	$H = H_0 K_r K_s$
•	322	42	STO	$\rightarrow R_3$
•	323	03	03	
	324	65	×	
	325	43	RCL	

* - DELETE IF PRINTER IS NOT AVAILABLE
R/S - INSERT IF PRINTER IS NOT AVAILABLE
• - DELETE IF H_1 NOT H_0 IS KNOWN

101A-7

STEP	KEY ENTRY	KEY CODE		COMMENTS
	326	13 13		
	327	65 ×		
	328	43 RCL		
	329	02 02		
	330	55 ÷		
	331	02 2		
	332	55 ÷		
	333	43 RCL		
	334	04 04		
	335	55 ÷		
	336	43 RCL		
	337	06 06		
	338	95 =		$\frac{H}{2}\ \frac{gt}{L}\ \frac{1}{\cosh(\frac{2\pi d}{L})}$
	339	42 STO		
	340	08 08		$\rightarrow R_8$
	341	91 R/S		
	342	76 LBL		
	343	17 B'		
	344	42 STO	*	$z \rightarrow R_{16}$
	345	16 16	*	
	346	04 4	*	
	347	06 6	*	"Z" PRINT CODE
	348	69 OP	*	
	349	04 04	*	
	350	43 RCL	*	
	351	16 16	*	
	352	69 OP	*	
	353	06 06	*	
	354	65 ×		
	355	02 2		
	356	65 ×		
	357	89 π		
	358	95 =		
	359	42 STO		$2\pi z \rightarrow R_{16}$
	360	16 16		
	361	91 R/S		
	362	76 LBL		
	363	18 C'		
	364	42 STO		$\Theta \rightarrow R_{15}$
	365	15 15		
	366	03 3	*	
	367	03 3	*	"PANG" PRINT CODE
	368	01 1	*	(PHASE ANGLE)
	369	03 3	*	
	370	03 3	*	
	371	01 1	*	
	372	02 2	*	
	373	02 2	*	
	374	69 OP	*	
	375	04 04	*	
	376	43 RCL	*	
	377	15 15	*	
	378	69 OP	*	PRINT Θ
	379	06 06	*	
•	380	02 2	*	
•	381	03 3	*	
•	382	69 OP	*	"H" PRINT CODE
•	383	04 04	*	
•	384	43 RCL		
•	385	03 03		
•	386	69 OP	*	PRINT H
• R/S →	387	06 06	*	
	388	43 RCL		
	389	16 16		
	390	85 +		
	391	43 RCL		
	392	11 11		
	393	95 =		
	394	55 ÷		
	395	43 RCL		
	396	04 04		
	397	95 =		
	398	42 STO		$\frac{2\pi(z+d)}{L} \rightarrow R_{14}$
	399	14 14		
	400	71 SBR		
	401	39 COS		$\cosh(R_{14})$
	402	65 ×		
	403	04 4	*	
	404	01 1	*	"U" PRINT CODE
	405	69 OP	*	
	406	04 04	*	
	407	43 RCL		
	408	08 08		
	409	65 ×		
	410	43 RCL		
	411	15 15		
	412	39 COS		$\cos\Theta$
	413	95 =		
	414	69 OP	*	PRINT U
R/S →	415	06 06	*	
	416	04 4	*	
	417	03 3	*	"W" PRINT CODE
	418	69 OP	*	
	419	04 04	*	
	420	43 RCL		
	421	14 14		
	422	71 SBR		$\sinh(R_{14})$
	423	38 SIN		
	424	65 ×		
	425	43 RCL		
	426	08 08		
	427	65 ×		
	428	43 RCL		
	429	15 15		$\sin\Theta$
	430	38 SIN		
	431	95 =		
	432	69 OP	*	
	433	06 06	*	PRINT W
	434	98 ADV	*	
	435	91 R/S		

* - DELETE IF PRINTER IS UNAVAILABLE
R/S - INSERT IF PRINTER IS UNAVAILABLE
• - DELETE IF H, NOT H_0 IS KNOWN

101A-8

Program Description

Program Title	102R Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle (RPN logic)
Name	T.L. Walton, Jr.
Date	10/80
Address	Coastal Engineering Research Center
City	Kingman Building, Fort Belvoir,
State	Virginia
Zip Code	22060

Program Description, Equations, Variables, etc.

This program calculates breaking wave height, H_b, and breaking wave angle, α_b, using linear wave theory approximations combined with the shallow-water breaking assumption. Input parameters are wave height, H, wave period, T, wave angle, α, and the water depth, d, where the preceding three variables are measured. An additional input parameter is nearshore beach slope, m. The ratio of the breaking wave height to the water depth at breaking is predicted using the equation

$$\kappa = H_b/d_b = 1.16\left(\frac{m}{\sqrt{H_o'/L_o}}\right)^{0.22}$$

from Singamsetti and Wind (1980), where d_b is the water depth at breaking, H_o' the deepwater wave height, and L_o the deepwater wavelength. This solution requires the assumption of straight and parallel offshore bottom contours for the application of Snell's law of refraction. Input wave parameters H, T, and α can be in any depth of water, d. Algorithm uses English or metric system of units. The development of the equation is derived on the attached solution sheet.

REFERENCES

SINGAMSETTI, S.R., and WIND, H.G., "Characteristics of Shoaling and Breaking Periodic Waves Normally Incident to Plane Beaches of Constant Slope," Report No. M1371, Toegepast Onberzoek Waterstaat, July 1980.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

Development of the equation:

From conservations of energy

$$\frac{\gamma H^2}{8} C_g \cos \alpha = \frac{\gamma H_i^2}{8} C_{gi} \cos \alpha_i \tag{1}$$

where the subscript i indicates incident wave parameters.

If left hand side of above equation represents conditions at breaking then

$$C_g = C = C_b = \sqrt{g d_b} = \sqrt{g H_b / \kappa} \tag{2}$$

where
$$\kappa = \frac{H_b}{d_b} \tag{3}$$

Now assume
$$\kappa = 1.16 \left(\frac{m}{\sqrt{H_o'/L_o}} \right)^{0.22} \tag{4}$$

where H_o' is unrefracted deepwater wave height.

Using (1), (2), (3), and (4) it can be found

$$H_b = \left\{ \left(\frac{\kappa}{g} \right)^{1/2} H_i^2 \, C_{gi} \cos \alpha_i \right\}^{2/5} \tag{5}$$

From Snell's law of refraction

$$\frac{\sin \alpha_b}{C_b} = \frac{\sin \alpha_i}{C_i}$$

therefore,

$$\sin \alpha_b = \left(\frac{\sin \alpha_i}{C_i} \right) \left\{ \left(\frac{g}{\kappa} H_b \right)^{1/2} \right\} \tag{7}$$

User Instructions

Program Title: 102R Linear Approximation to Breaking Wave Height and Breaking Wave Angle

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	ENTER BOTTOM SLOPE m (TANGENT)	m	A	m
2	ENTER DEPTH d (FEET OR METERS)	d (FT or M)	B	2π d
3	ENTER WAVE ANGLE α (DEGREES) AT DEPTH d		C	α
4	ENTER WAVE HEIGHT H (FT or M) AT DEPTH d		D	H
5	ENTER WAVE PERIOD T (SECONDS) AND PRESS E FOR ENGLISH UNITS OR PRESS f e FOR METRIC UNITS	T (SEC)	E / f e	
6	READ kd IN DISPLAY			kd
7	PRESS R/S AND READ n		R/S	n
8	PRESS R/S AND READ Cg (FT or M)		R/S	Cg
9	PRESS R/S AND READ Ks		R/S	Ks
10	PRESS R/S AND READ H'o (FT or M)		R/S	H'o
11	PRESS R/S AND READ Hb (FT or M)		R/S	Hb
12	PRESS R/S AND READ αb (DEGREES)		R/S	αb
	EXAMPLE :			
	T = 8 SEC, H = 18 FT, α = 30°, d = 50 FT, m = 0.10			
	ENTER m = 0.10, PRESS A	0.10	A	0.10
	ENTER d = 50 FT, PRESS B	50	B	50.00
	ENTER α = 30°, PRESS C	30	C	30.00
	ENTER H = 18 FT, PRESS D	18	D	18.00
	ENTER T = 8 SEC, PRESS E	8	E	
	READ kd IN DISPLAY			1.16
	PRESS R/S AND READ n = 0.73		R/S	0.73
	PRESS R/S AND READ Cg = 24.62 F/S		R/S	24.62
	PRESS R/S AND READ Ks = 0.91		R/S	0.91
	PRESS R/S AND READ H'o = 19.73 FT		R/S	19.73
	PRESS R/S AND READ Hb = 16.98 FT		R/S	16.98
	PRESS R/S AND READ αb = 20.79		R/S	20.79

102R-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	
	STO E	33 15	$m \rightarrow R_E$
	R/S	84	
	f LBL B	31 25 12	
	STO 1	33 01	$d \rightarrow R_1$
	h π	35 73	
	X	71	
	2	02	
	X	71	
010	STO B	33 12	$2\pi d \rightarrow R_B$
	R/S	84	
	f LBL C	31 25 13	
	STO 0	33 00	$\alpha \rightarrow R_0$
	R/S	84	
	f LBL D	31 25 14	
	STO 8	33 08	$H \rightarrow R_8$
	R/S	84	
	g LBL e	32 25 15	
	STO 2	33 02	$T \rightarrow R_2$
020	9	09	
	•	83	
	8	08	
	1	01	
	STO D	33 14	$g_{(METRIC)} \rightarrow R_D$
	GTO ÷ b	22 31 12	
	f LBL E	32 25 15	
	STO 2	33 02	$T \rightarrow R_2$
	3	03	
	2	02	
030	•	83	
	2	02	
	STO D	33 14	$g_{(ENGLISH)} \rightarrow R_D$
	g LBL f b	32 25 12	
	RCL 2	34 02	
	g x^2	32 54	
	RCL D	34 14	
	X	71	
	2	02	
	÷	81	
040	h π	35 73	
	÷	81	
	STO 3	33 03	$L_0 = \frac{gT^2}{2\pi} \rightarrow R_3$
	g LBL f d	32 25 14	
	STO A	33 11	$L_{OLD} \rightarrow R_A$
	h $\sqrt{x}$	35 62	
	RCL B	34 12	
	X	71	
	STO C	33 13	$\frac{2\pi d}{L_{old}} \rightarrow R_C$
	÷ GSB 2	31 22 02	
050	STO 6	33 06	$\cosh(R_C) \rightarrow R_6$
	RCL C	34 13	
	f GSB 1	31 22 01	
	STO 5	33 05	$\sinh(R_C) \rightarrow R_5$
	RCL 6	34 06	
	÷	81	
	RCL 3	34 03	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	X	71	
	RCL A	34 11	
	+	61	
060	2	02	
	÷	81	
	STO 4	33 04	$L_{NEW} \rightarrow R_4$
	RCL A	34 11	
	−	51	
	h ABS	35 64	
	1	01	
	g x>y	32 81	
	GTO f c	22 31 13	
	RCL 4	34 04	
070	GTO f d	22 31 14	
	g LBL f e	32 25 13	
	RCL B	34 12	
	RCL 4	34 04	
	÷	81	
	STO 9	33 09	$Kd \rightarrow R_9$
	R/S	84	Kd IN DISPLAY
	2	02	
	X	71	
	STO A	33 11	$\frac{4\pi d}{L} \rightarrow R_A$
080	f GSB 1	31 22 01	
	h y_x	35 62	
	RCL A	33 11	
	X	71	
	1	01	
	+	61	
	2	02	
	÷	81	
	STO 1	33 01	$n \rightarrow R_1$
	R/S	84	n IN DISPLAY
090	RCL 4	34 04	
	X	71	
	RCL 2	34 02	
	÷	81	
	STO 4	33 04	$C_8 \rightarrow R_4$
	R/S	84	C_8 IN DISPLAY
	h y_x	35 62	
	RCL 2	34 02	
	X	71	
	RCL D	34 14	
100	X	71	
	4	04	
	÷	81	
	h π	35 73	
	÷	81	
	f $\sqrt{x}$	31 54	
	STO A	33 11	$K_5 = \sqrt{\frac{C_{80}}{C_8}} \rightarrow R_A$
	R/S	84	K_5 IN C_8 DISPLAY
	RCL 8	34 08	
	RCL A	34 11	
110	÷	81	$H'_0 = H/K_5$
	R/S	84	H'_0 IN DISPLAY
	RCL 3	34 03	

102R-4

STEP	KEY ENTRY	KEY CODE	COMMENTS
	÷	81	
	f √x	31 54	
	RCL E	34 15	
	÷	81	
	h y^x	35 62	
	.	83	
	2	02	
120	2	02	
	h y^x	35 63	
	1	01	
	.	83	
	1	01	
	6	06	
	x	71	
	RCL D	34 19	
	÷	81	
	STO 6	33 06	$\frac{K}{g} = \frac{L_{16}}{g}\left(\frac{(n)}{\sqrt{H_o/L_o}}\right)^{0.22}$
130	RCL B	34 08	→ R_6
	g x^2	32 54	
	RCL 4	34 04	
	x	71	
	RCL 0	34 00	
	f cos	31 63	
	x	71	
	.	83	
	4	04	
	h y^x	35 63	
140	RCL 6	34 06	
	.	83	
	2	02	
	h y^x	35 63	
	x	71	
	R/S	84	$\left(\frac{K}{g}\right)^{Y_5}(H^2 C_g \cos\alpha)^{3/5} = H_b$
	RCL 6	34 06	IN DISPLAY
	h y^x	35 62	
	x	71	
	f √x	31 54	
150	RCL 0	34 00	
	f sin	31 62	
	x	71	
	RCL 4	34 04	$\frac{\sin\alpha}{C}\left(\frac{g}{K} H_b\right)^{Y_2} =$
	÷	81	$\sin\alpha_b$
	RCL 1	34 01	
	x	71	
	g $\sin^{-1}$	32 62	
	R/S	84	α_b IN DISPLAY
	f LBL 1	31 25 01	
160	STO 7	33 07	
	g e^x	32 52	
	RCL 7	34 07	SUBROUTINE
	CHS	42	SINh ()
	g e^x	32 52	
	−	51	
	2	02	
	÷	81	
	h RTN	35 22	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	f LBL 2	31 25 02	
170	STO 7	33 07	
	g e^x	32 52	
	RCL 7	34 07	SUBROUTINE
	CHS	42	COSh ()
	g e^x	32 52	
	+	61	
	2	02	
	÷	81	
	h RTN	35 22	
180			
190			
200			
210			
220			

102R-5

Program Description

Program Title	102A Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle (AOS logic)
Name	W.A. Birkemeier — Date 5/81
Address	CERC Field Research Facility
City	Kitty Hawk, — State North Carolina Zip Code 27949

Program Description, Equations, Variables, etc.

This program calculates breaking wave height, H_b, and breaking wave angle, α_b, using linear wave theory approximations combined with the shallow-water breaking assumption. Input parameters are wave height, H, wave period, T, wave angle, α, and the water depth, d, where the preceding three variables are measured. An additional input parameter is nearshore beach slope, m. The ratio of the breaking wave height to the water depth at breaking is predicted using the equation

$$\kappa = H_b/d_b = 1.16\left(\frac{m}{\sqrt{H_o'/L_o}}\right)^{0.22}$$

from Singamsetti and Wind (1980), where d_b is the water depth at breaking, H_o' the deepwater wave height, and L_o the deepwater wavelength. This solution requires the assumption of straight and parallel offshore bottom contours for the application of Snell's law of refraction. Input wave parameters H, T, and α can be in any depth of water, d. Algorithm uses English or metric system of units. The development of the equation is derived on the solution sheet included with program 102R.

REFERENCES

SINGAMSETTI, S.R., and WIND, H.G., "Characteristics of Shoaling and Breaking Periodic Waves Normally Incident to Plane Beaches on Constant Slope," Report No. M1371, Toegepast Onberzoek Waterstaat, July 1980.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

User Instructions

Program Title: 102A Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	ENTER BOTTOM SLOPE m (TANGENT)	m	A	M
2	ENTER DEPTH d (ft OR M)	d (ft OR M)	B	2πd
3	ENTER WAVE ANGLE AT DEPTH d, α (DEGREES)	α	C	α
4	ENTER WAVE HEIGHT AT DEPTH d, H (ft OR M)	H (ft OR M)	D	H
5	ENTER WAVE PERIOD T (SEC)			
	PRESS E FOR ENGLISH UNITS	T (SEC)	E	
	PRESS E' FOR METRIC UNITS		E'	
	NOTE: WITH PRINTER THE FOLLOWING WAVE			
	PARAMETERS ARE PRINTED AND LABELED			
	Kd, n, Cg, Ks, H_o', H_b, α_b			
	WITHOUT PRINTER:			
6	READ Kd IN DISPLAY			Kd
7	PRESS R/S AND READ n		R/S	n
8	PRESS R/S AND READ Cg (ft/SEC OR M/SEC)		R/S	Cg
9	PRESS R/S AND READ Ks		R/S	Ks
10	PRESS R/S AND READ H_o' (ft OR M)		R/S	H_o'
11	PRESS R/S AND READ H_b (ft OR M)		R/S	H_b
12	PRESS R/S AND READ α_b		R/S	α_b
	TO REPEAT ENTER ANY INPUT VARIABLE m, d, α, H			
	AND T. WAVE PERIOD MUST BE ENTERED OR			
	RE-ENTERED.			
	EXAMPLE: CALCULATE WAVE PARAMETERS AND			
	BREAKING WAVE HEIGHT AND DIRECTION FOR:			
	T = 8SEC			
	H = 18ft			
	α = 30°			
	d = 50ft			
	m = 0.1			

102A-2

User Instructions

Program Title: 102A Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	ENTER m = 0.1 PRESS A	0.1	A	0.1
	ENTER d = 50ft PRESS B	50 ft	B	314.16
	ENTER α = 30° PRESS C	30°	C	30°
	ENTER H = 18ft PRESS D	18ft	D	18
	ENTER T = 8SEC PRESS E	8 SEC	E	
	WITH PRINTER Kd, n, Cg, Ks, H_o', Hb,			
	AND α_b ARE PRINTED AND LABELED,			
	OTHERWISE:			
	READ Kd IN DISPLAY			1.163
	PRESS R/S READ n = 0.729		R/S	0.729
	PRESS R/S READ Cg = 24.624 (ft/SEC)		R/S	24.625
	PRESS R/S READ Ks = 0.912		R/S	0.912
	PRESS R/S READ H_o' = 19.728 (ft)		R/S	19.728
	PRESS R/S READ Hb = 16.981 (ft)		R/S	16.981
	PRESS R/S READ α_b = 20.786°		R/S	20.786°
	PRINTED OUTPUT OF EXAMPLE			
	0.1 M			
	50. D			
	30. ANG			
	18. H			
	8. T			
	1.16314388 KD			
	0.729367164 N			
	24.62479667 CG			
	.9123924245 KS			
	19.72835319 HO'			
	16.98073853 HB			
	20.78594881 ANGB			

102A-3

Program Listing

STEP	KEY ENTRY	KEY CODE		COMMENTS
000	76	LBL		
001	11	A		
002	42	STO		M → R14
003	14	14		
004	03	3	*	"M" PRINT CODE
005	00	0	*	
006	69	OP	*	
007	04	04	*	
008	43	RCL	*	
009	14	14	*	
010	69	OP	*	PRINT M
011	06	06	*	
012	91	R/S		
013	76	LBL		
014	12	B		
015	42	STO		d → R1
016	01	01		
017	01	1	*	"D" PRINT CODE
018	06	6	*	
019	69	OP	*	
020	04	04	*	
021	43	RCL	*	
022	01	01	*	
023	69	OP	*	PRINT d
024	06	06	*	
025	65	×		
026	89	π		
027	65	×		
028	02	2		
029	95	=		
030	42	STO		2πd → R11
031	11	11		
032	91	R/S		
033	76	LBL		
034	13	C		
035	42	STO		α → R0
036	00	00		
037	01	1	*	
038	03	3	*	"ANG" PRINT CODE
039	03	3	*	
040	01	1	*	
041	02	2	*	
042	02	2	*	
043	69	OP	*	
044	04	04	*	
045	43	RCL	*	
046	00	00	*	
047	69	OP	*	
048	06	06	*	
049	91	R/S		
050	76	LBL		
051	14	D		
052	42	STO		H → R8
053	08	08		
054	02	2	*	"H" PRINT CODE
055	03	3	*	
056	69	OP	*	
057	04	04	*	
058	43	RCL	*	
059	08	08	*	
060	69	OP	*	
061	06	06	*	PRINT H
062	91	R/S		
063	76	LBL		SUBROUTINE TO COMPUTE
064	38	SIN		
065	42	STO		
066	07	07		SIN h (x)
067	22	INV		
068	23	LNX		
069	75	-		
070	43	RCL		
071	07	07		
072	94	+/-		
073	22	INV		
074	23	LNX		
075	95	=		
076	55	÷		
077	02	2		
078	95	=		
079	92	RTN		
080	76	LBL		SUBROUTINE TO COMPUTE cos h (x)
081	39	COS		
082	42	STO		
083	07	07		
084	22	INV		
085	23	LNX		
086	85	+		
087	43	RCL		
088	07	07		
089	94	+/-		
090	22	INV		
091	23	LNX		
092	95	=		
093	55	÷		
094	02	2		
095	95	=		
096	92	RTN		
097	76	LBL		E' ALLOWS METRIC DATA ENTRY
098	10	E'		
099	42	STO		
100	02	02		T → R2
101	09	9		
102	93	.		g = 9.81
103	08	8		
104	01	1		
105	42	STO		g → R13
106	13	13		
107	03	3	*	

102A-4

*- DELETE IF PRINTER IS NOT AVAILABLE

STEP	KEY ENTRY	KEY CODE		COMMENTS
108	00	0	*	"M" PRINT CODE
109	69	DP	*	
110	04	04	*	
111	69	DP	*	
112	05	05	*	
113	17	B'		
114	76	LBL		
115	15	E		"E" ALLOWS
116	42	STO		ENGLISH UNITS
117	02	02		$T \rightarrow R_2$
118	03	3		
119	02	2		$g = 32.2$ ft/sec^2
120	93	.		
121	02	2		
122	42	STO		
123	13	13		$\rightarrow R_{13}$
124	76	LBL		
125	17	B'		
126	01	1		$1 \rightarrow t$ REGISTER
127	32	X:T		
128	03	3	*	
129	07	7	*	"T" PRINT CODE
130	69	DP	*	
131	04	04	*	
132	43	RCL		
133	02	02		
134	69	DP	*	
135	06	06	*	PRINT T
136	33	X^2		
137	65	×		
138	43	RCL		
139	13	13		
140	55	÷		
141	02	2		
142	55	÷		
143	89	π		
144	95	=		$L_0 = gT^2/2\pi$
145	42	STO		
146	03	03		$\rightarrow R_3$
147	76	LBL		
148	19	D'		
149	42	STO		
150	10	10		$L_{OLD} \rightarrow R_{10}$
151	35	1/X		
152	65	×		
153	43	RCL		
154	11	11		
155	95	=		
156	42	STO		$\frac{2\pi d}{L_{OLD}} \rightarrow R_{12}$
157	12	12		
158	71	SBR		
159	39	COS		$\cosh\left(\frac{2\pi d}{L_{OLD}}\right) \rightarrow R_6$
160	42	STO		
161	06	06		

STEP	KEY ENTRY	KEY CODE		COMMENTS
162	43	RCL		
163	12	12		
164	71	SBR		
165	38	SIN		$\sinh\left(\frac{2\pi d}{L_{OLD}}\right) \rightarrow R_5$
166	42	STO		
167	05	05		
168	55	÷		
169	43	RCL		
170	06	06		
171	65	×		
172	43	RCL		
173	03	03		
174	85	+		
175	43	RCL		
176	10	10		
177	95	=		
178	55	÷		
179	02	2		
180	95	=		
181	42	STO		$L_{NEW} \rightarrow R_4$
182	04	04		
183	75	-		
184	43	RCL		
185	10	10		
186	95	=		
187	50	I×I		ITERATE UNTIL
188	22	INV		$L_{NEW} - L_{OLD} < t$
189	77	GE		WHERE t IS VALUE
190	18	C'		IN t register
191	43	RCL		
192	04	04		
193	19	D'		
194	76	LBL		
195	18	C'		
196	43	RCL		
197	11	11		
198	55	÷		
199	02	2	*	
200	06	6	*	"KD" PRINT CODE
201	01	1	*	
202	06	6	*	
203	69	DP	*	
204	04	04	*	
205	43	RCL		
206	04	04		
207	95	=		
208	42	STO		$\frac{2\pi d}{L} = Kd \rightarrow R_9$
209	09	09		
210	69	DP	*	
R/S SEE BELOW → 211	06	06	*	PRINT Kd
212	65	×		
213	02	2		
214	95	=		
215	42	STO		

102A-5

*- DELETE IF PRINTER IS UNAVAILABLE
R/S - INSERT IF PRINTER IS UNAVAILABLE

STEP	KEY ENTRY	KEY CODE		COMMENTS
	216	10 E'		$\frac{4\pi d}{L} \rightarrow R_{10}$
	217	71 SBR		
	218	38 SIN		
	219	35 1/X		
	220	65 ×		
	221	43 RCL		
	222	10 10		
	223	85 +		
	224	01 1		
	225	95 =		
	226	55 ÷		
	227	03 3	*	
	228	01 1	*	"N" PRINT CODE
	229	69 □P	*	
	230	04 04	*	
	231	02 2		
	232	95 =		
	233	42 STO		
	234	01 01		$n \rightarrow R_1$
	235	69 □P	*	
	236	06 06	*	PRINT n
	237	65 ×		
	238	01 1	*	
	239	05 5	*	
	240	02 2	*	"CG" PRINT CODE
	241	02 2	*	
	242	69 □P	*	
	243	04 04	*	
	244	43 RCL		
	245	04 04		
	246	55 ÷		
	247	43 RCL		
	248	02 02		
	249	95 =		
	250	42 STO		
	251	04 04		$CG \rightarrow R_4$
	252	69 □P	*	
	253	06 06	*	PRINT C_g
	254	35 1/X		
	255	65 ×		
	256	02 2	*	
	257	06 6	*	
	258	03 3	*	"KS" PRINT CODE
	259	06 6	*	
	260	69 □P	*	
	261	04 04	*	
	262	43 RCL		
	263	02 02		
	264	65 ×		
	265	43 RCL		
	266	13 13		
	267	55 ÷		
	268	04 4		
	269	55 ÷		

STEP	KEY ENTRY	KEY CODE		COMMENTS
	270	89 π		
	271	95 =		
	272	34 √X		
	273	42 STO		
	274	10 10		$K_s = \sqrt{\frac{C_{g_0}}{C_g}} \rightarrow R_{10}$
	275	69 □P	*	
R/S SEE BELOW →	276	06 06	*	PRINT K_s
	277	02 2	*	STEPS 277 TO 379
	278	03 3	*	
	279	00 0	*	COMPUTE H_s AND ω_b
	280	01 1	*	"H0" PRINT CODE
	281	06 6	*	
	282	05 5	*	
	283	69 □P	*	
	284	04 04	*	
	285	43 RCL		
	286	08 08		
	287	55 ÷		
	288	43 RCL		$H_0' = \frac{H}{K_s}$
	289	10 10		
	290	95 =		
	291	69 □P	*	
R/S SEE BELOW →	292	06 06	*	PRINT H_0'
	293	55 ÷		
	294	43 RCL		
	295	03 03		
	296	95 =		
	297	34 √X		
	298	55 ÷		
	299	43 RCL		
	300	14 14		
	301	95 =		
	302	35 1/X		
	303	45 Y^X		
	304	93 .		
	305	02 2		
	306	02 2		
	307	65 ×		
	308	01 1		
	309	93 .		
	310	01 1		
	311	06 6		
	312	55 ÷		
	313	43 RCL		
	314	13 13		
	315	95 =		
	316	42 STO		$\frac{K}{g} = \frac{1.16}{g}\left(\frac{\frac{n}{\sqrt{H_0}}}{L_0}\right)^{.22}$
	317	06 06		
	318	43 RCL		
	319	08 08		$\rightarrow R_6$
	320	33 X²		
	321	65 ×		
	322	43 RCL		
	323	04 04		

102A-6

* - DELETE IF PRINTER IS UNAVAILABLE
R/S - INSERT IF PRINTER IS UNAVAILABLE

STEP	KEY ENTRY	KEY CODE		COMMENTS
	324	65 ×		
	325	43 RCL		
	326	00 00		
	327	39 COS		
	328	95 =		
	329	45 Y×		
	330	93 .		
	331	04 4		$(H^2 C_g \cos\alpha)^{2/5}$
	332	65 ×		
	333	02 2	*	
	334	03 3	*	
	335	01 1	*	
	336	04 4	*	'HB' PRINT CODE
	337	69 OP	*	
	338	04 04	*	
	339	43 RCL		
	340	06 06		
	341	45 Y×		
	342	93 .		
	343	02 2		$(\frac{K}{g})^{.2} (H^2 C_g \cos\alpha)^{2/5}$
	344	95 =		
	345	69 OP	*	
	346	06 06	*	PRINT H_b
R/S SEE BELOW →	347	65 ×		
	348	43 RCL		
	349	06 06		
	350	35 1/X		
	351	95 =		
	352	34 FX		
	353	65 ×		
	354	43 RCL		
	355	00 00		
	356	38 SIN		
	357	55 ÷		
	358	01 1	*	
	359	03 3	*	
	360	03 3	*	
	361	01 1	*	"ANGB" PRINT CODE
	362	02 2	*	
	363	02 2	*	
	364	01 1	*	
	365	04 4	*	
	366	69 OP	*	
	367	04 04	*	
	368	43 RCL		
	369	04 04		
	370	65 ×		
	371	43 RCL		
	372	01 01		
	373	95 =		$\sin\alpha_b = \frac{\sin\alpha}{C_i} (\frac{g}{K} H_b)^{1/2}$
	374	22 INV		
	375	38 SIN		
	376	69 OP	*	
	377	06 06	*	PRINT α_b

STEP	KEY ENTRY	KEY CODE	COMMENTS
	378	98 ADV	
	379	91 R/S	
180			
190			
200			
210			
220			

102A-7

*-DELETE IF PRINTER IS UNAVAILABLE
R/S-INSERT IF PRINTER IS UNAVAILABLE

Program Description

Program Title	103R Shallow-Water Wave Forecasting Equations (RPN logic)				
Name	T.L. Walton, Jr.			**Date**	10/80
Address	Coastal Engineering Research Center				
City	Kingman Building Fort Belvoir,	**State**	Virginia	**Zip Code**	22060

Program Description, Equations, Variables, etc.

This algorithm computes the wave height, H, wave period, T, and minimum duration, t, from input values of the water depth, d, fetch length, F, and adjusted windspeed, U_A, using equations (1), (2), and (3) of CETN-I-6. Equations (1) and (2) are for constant water depth and unlimited wind duration and have been revised from equations (3-25) and (3-26) of the Shore Protection Manual. Wave height and period in this algorithm are significant wave height and period. Algorithm uses English or metric system of units.

REFERENCES

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I, II, and III, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, 1,262 pp.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Method for Determining Adjusted Windspeed, U_A, for Wave Forecasting," CETN-I-5, Fort Belvoir, Va., 1981.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Shallow Water," CETN-I-6, Fort Belvoir, Va., 1981.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Deep Water," CETN-I-7, Fort Belvoir, Va., 1981.

Operating Limits and Warnings

User Instructions

Program Title: 103R Shallow Water Wave Forecasting Equations

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	ENTER ADJUSTED WIND SPEED	U_A(MPH)		
	U_A IN EITHER MPH OR KPH	U_A(KPH)	A	U_A
2	ENTER FETCH LENGTH F IN	F (MI)		
	EITHER MILES OR KILOMETERS	F (KM)	B	F
3	ENTER DEPTH d IN FEET			
	OR IN METERS		C	d
4	TO COMPUTE H,T IN ENGLISH UNITS			
	PRESS E, READ H		E	H (FT)
5	PRESS R/S, READ T		R/S	T (SEC)
6	PRESS R/S, READ t.		R/S	t (HOURS)
	OR			
4a	TO COMPUTE H,T IN METRIC UNITS			
	PRESS f e, READ H (M)		f e	H (M)
	PRESS R/S, READ T (SEC)		R/S	T (SEC)
	EXAMPLE			
	U_A = 40 MPH; F = 300 M; d = 20 FT			
	ENTER U_A = 40 MPH, PRESS A	40	A	40.00
	ENTER F = 300 M, PRESS B	300	B	300.00
	ENTER d = 20 FT, P	20	C	20.00
	PRESS E, READ H = 4.53 FT		E	4.53 (FT)
	PRESS R/S, READ T = 5.60 SEC		R/S	5.60 (SEC)
	PRESS R/S, READ t = 3.73 HRS		R/S	3.73 (HRS)

103R-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	$U_A \rightarrow R_3$
	STO 3	33 03	
	R/S	84	
	f LBL B	31 25 12	$F \rightarrow R_5$
	STO 5	33 05	
	R/S	84	
	f LBL C	31 25 13	$d \rightarrow R_6$
	STO 6	33 06	
	R/S	84	
010	f LBL E	31 25 15	
	3	03	
	2	02	
	.	83	
	2	02	
	STO 9	33 09	g(ENGLISH) $\rightarrow R_9$
	1	01	
	.	83	
	4	04	
	7	07	
020	STO 7	33 07	CONVERSION FACTOR $\rightarrow R_7$
	5	05	
	2	02	
	8	08	
	0	00	
	STO 1	33 01	CONVERSION FACTOR $\rightarrow R_1$
	GTO f d	22 31 14	
	g LBL f e	32 25 15	
	9	09	
	.	83	
030	8	08	
	1	01	
	STO 9	33 09	g(METRIC) $\rightarrow R_9$
	.	83	
	2	02	
	7	07	
	7	07	
	8	08	
	STO 7	33 07	CONVERSION FACTOR $\rightarrow R_7$
	1	01	
040	0	00	
	0	00	
	0	00	
	STO 1	33 01	CONVERSION FACTOR $\rightarrow R_1$
	g LBL f d	32 25 14	
	RCL 3	34 03	
	RCL 7	34 07	
	X	71	
	STO 7	33 07	$U_A \rightarrow R_7$ CONVERTED
	RCL 9	34 09	
050	RCL 7	34 07	
	g X^2	32 52	
	÷	81	$g/U_A^2 \rightarrow R_8$
	STO 8	33 08	
	RCL 6	34 06	
	X	71	$g d/U_A^2 \rightarrow R_0$
	STO 0	33 00	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	RCL 6	34 06	
	RCL 1	34 01	
	X	71	
080	RCL 5	34 05	
	X	71	$\frac{2F}{U_A^2} \rightarrow R_1$
	STO 1	33 01	
	RCL 0	34 00	
	.	83	
	7	07	
	5	05	
	h Y^x	35 63	
	.	83	
	5	05	
090	3	03	
	X	71	
	f GSB 1	31 22 01	$\tanh\left[.53\left(\frac{2d}{U_A^2}\right)^{.75}\right]$
	STO 4	33 04	
	RCL 1	34 01	$\rightarrow R_4$
	f $\sqrt{x}$	31 54	
	.	83	
	0	00	
	0	00	
	5	05	
100	6	06	
	5	05	
	X	71	
	RCL 4	34 04	
	÷	81	$\tanh\left[\frac{.00666}{R4}\left(\frac{2F}{U_A}\right)^{.5}\right]$
	f GSB 1	31 22 01	
	RCL 4	34 04	
	X	71	
	.	83	
	2	02	
110	8	08	
	3	03	
	X	71	
	RCL B	34 08	
	÷	81	
	R/S	84	H IN DISPLAY
	RCL 0	34 00	
	.	83	
	3	03	
	7	07	
120	5	05	
	h y^x	35 63	
	.	83	
	8	08	
	5	05	
	3	05	
	X	71	
	f GSB 1	31 22 01	$\tanh\left[.833\left(\frac{2d}{U_A^2}\right)^{.375}\right]$
	STO 4	33 04	
	RCL 1	34 01	$\rightarrow R_4$
130	.	83	
	3	03	
	3	03	

103R-3

STEP	KEY ENTRY	KEY CODE	COMMENTS
	3	03	
	h y^x	35 63	
	.	83	
	0	00	
	3	03	
	7	07	
	9	09	
120	X	71	
	RCL 4	34 04	
	÷	81	
	f GSB 1	31 22 01	$\tanh\left[\frac{.0379\left(\frac{\&F}{UA^2}\right)^{.333}}{R_4}\right.$
	RCL 4	34 04	
	X	71	
	7	07	
	.	83	
	5	05	
	4	04	
130	X	71	
	RCL 8	34 08	
	÷	81	
	RCL 7	34 07	
	÷	81	
	RIS	84	T IN DISPLAY
	RCL 9	34 09	
	X	71	
	RCL 7	34 07	
	÷	81	
140	2	02	
	.	83	
	3	03	
	3	03	
	3	03	
	h y^x	35 63	
	5	05	
	3	03	
	7	07	
	X	71	
150	RCL 7	34 07	
	X	71	
	RCL 9	34 09	
	÷	81	t (SECONDS)
	3	03	
	6	06	
	0	00	
	0	00	
	÷	81	
	RIS	84	t (HRS) IN DISPLAY
160	f LBL 1	31 25 01	SUBROUTINE tAN h ()
	STO 2	33 02	
	& e^x	32 52	
	RCL 2	34 02	
	CHS	42	
	& e^x	32 52	
	−	51	
	RCL 2	34 02	
	& e^x	32 52	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	RCL 2	34 02	
170	CHS	42	
	& e^x	32 52	
	+	61	
	÷	81	
	h RTN	35 22	
180			
190			
200			
210			
220			

103R-4

Program Description

Program Title	103A Shallow-Water Wave Forecasting Equations (AOS logic)				
Name	W.A. Birkemeier			**Date**	5/81
Address	CERC Field Research Facility				
City	Kitty Hawk,	**State**	North Carolina	**Zip Code**	27949

Program Description, Equations, Variables, etc.

This algorithm computes the wave height, H, wave period, T, and minimum duration, t, from input values of the water depth, d, fetch length, F, and adjusted windspeed, U_A, using equations (1), (2), and (3) of CETN-I-6. Equations (1) and (2) are for constant water depth and unlimited wind duration and have been revised from equations (3-25) and (3-26) of the Shore Protection Manual. Wave height and period in this algorithm are significant wave height and period. Algorithm uses English or metric system of units.

REFERENCES

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I, II, and III, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, 1,262 pp.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Method for Determining Adjusted Windspeed, U_A, for Wave Forecasting," CETN-I-5, Fort Belvoir, Va., 1981.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Shallow Water," CETN-I-6, Fort Belvoir, Va., 1981.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Deep Water," CETN-I-7, Fort Belvoir, Va., 1981.

Operating Limits and Warnings

User Instructions

Program Title: 103A Shallow-Water Wave Forecasting Equations

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	ENTER ADJUSTED WIND SPEED			
	(UA) IN EITHER MPH OR KPH	UA	A	UA
2	ENTER FETCH LENGTH (F) IN EITHER			
	MILES OR KILOMETERS	F	B	F
3	ENTER DEPTH (d) IN FEET OR METERS	d	C	d
4	TO COMPUTE H, T, AND t			
	PRESS E FOR ENGLISH UNITS		E	
	PRESS E' FOR METRIC UNITS		2nd E'	
	WITH PRINTER, H, T, AND t ARE			
	AUTOMATICALLY PRINTED AND LABELED			
	OTHERWISE:			
5	READ H IN DISPLAY (ft or m)			H (ft or m)
6	PRESS R/S AND READ T IN DISPLAY		R/S	T (sec)
7	PRESS R/S AND READ THE MINIMUM			
	DURATION t IN HOURS		R/S	t (hrs)
	EXAMPLE: COMPUTE SIGNIFICANT WAVE			
	HEIGHT AND PERIOD FOR THE FOLLOWING			
	CONDITIONS U_A = 40 mph			
	F = 300 m.			
	d = 20 ft.			
	ENTER UA = 40 PRESS A	40 MPH	A	40
	ENTER F = 300 PRESS B	300 mi	B	300
	ENTER d = 20 PRESS C	20 ft	C	20
	PRESS E AND READ H = 4.53 ft			4.53 ft
	PRESS R/S AND READ T = 5.60 SEC		R/S	5.60 SEC
	PRESS R/S AND READ. t = 3.73 HRS		R/S	3.73 hrs
	PRINTOUT OF EXAMPLE			
	40. UA			
	300. F			
	20. D			
	4.531271188 H			
	5.603173088 T			
	3.726684287 HRS			

103A-2

STEP	KEY ENTRY	KEY CODE	COMMENTS
000	76	LBL	
001	11	A	
002	42	STO	$U_A \rightarrow R_{10}$
003	10	10	
004	04	4 *	
005	01	1 *	"U_A" PRINT CODE
006	01	1 *	
007	03	3 *	
008	69	OP *	
009	04	04 *	
010	43	RCL *	
011	10	10 *	
012	69	OP *	PRINT U_A
013	06	06 *	
014	91	R/S	
015	76	LBL	
016	12	B	
017	42	STO	$F \rightarrow R_5$
018	05	05	
019	02	2 *	"F" PRINT CODE
020	01	1 *	
021	69	OP *	
022	04	04 *	
023	43	RCL *	
024	05	05 *	
025	69	OP *	PRINT F
026	06	06 *	
027	91	R/S	
028	76	LBL	
029	13	C	
030	42	STO	$d \rightarrow R_6$
031	06	06	
032	01	1 *	"D" PRINT CODE
033	06	6 *	
034	69	OP *	
035	04	04 *	
036	43	RCL *	
037	06	06 *	
038	69	OP *	PRINT d
039	06	06 *	
040	91	R/S	
041	76	LBL	LBLE - SELECTS ENGLISH UNITS
042	15	E	
043	03	3	
044	02	2	$g = 32.2\ ft/sec^2$
045	93	.	
046	02	2	
047	42	STO	$g \rightarrow R_9$
048	09	09	
049	01	1	TO CONVERT U_A TO ft/sec (MULTIPLY BY 1.47)
050	93	.	
051	04	4	
052	07	7	
053	42	STO	$1.47 \rightarrow R_7$
054	07	07	
055	05	5	
056	02	2	TO CONVERT F TO FEET (MULTIPLY BY 5280)
057	08	8	
058	00	0	
059	42	STO	$\rightarrow 01$
060	01	01	
061	19	D'	
062	76	LBL	LBL E SELECTS METRIC UNITS
063	10	E'	
064	09	9	
065	93	.	
066	08	8	$g = 9.81$
067	01	1	
068	42	STO	$g \rightarrow R_9$
069	09	09	
070	93	.	CONVERT U_a TO M/SEC MULTIPLY kph BY 0.2778
071	02	2	
072	07	7	
073	07	7 *	
074	08	8	
075	42	STO *	$\rightarrow R_7$
076	07	07	
077	01	1	CONVERT F TO METERS MULTIPLY km. BY 1000
078	00	0	
079	00	0	
080	00	0	
081	42	STO	$\rightarrow R_{01}$
082	01	01	
083	03	3 *	
084	00	0 *	"M" PRINT CODE
085	69	OP *	
086	04	04 *	
087	69	OP *	PRINT "M" TO
088	05	05 *	INDICATE METRIC
089	76	LBL	
090	19	D'	
091	43	RCL	CONVERT U_A
092	10	10	STORE IN R_7
093	49	PRD	
094	07	07	
095	43	RCL	
096	09	09	
097	55	÷	
098	43	RCL	
099	07	07	
100	33	X^2	
101	95	=	
102	42	STO	$g/U_A^2 \rightarrow R_8$
103	08	08	
104	49	PRD	
105	01	01	
106	65	×	
107	43	RCL	

103A-3

STEP	KEY ENTRY	KEY CODE		COMMENTS
	108	06	06	
	109	95	=	
	110	42	STO	$dg/U_A{}^2 \rightarrow R_0$
	111	00	00	
	112	43	RCL	
	113	05	05	
	114	49	PRD	$Fg/U^2 \rightarrow R_1$
	115	01	01	
	116	02	2 *	"H" PRINT CODE
	117	03	3 *	
	118	69	OP *	
	119	04	04 *	
	120	43	RCL	
	121	00	00	
	122	45	Y^x	
	123	93	.	
	124	07	7	
	125	05	5	
	126	65	×	
	127	93	.	
	128	05	5	
	129	03	3	
	130	95	=	
	131	71	SBR	
	132	30	TAN	$\tanh\left[.53\left(\frac{gd}{U_A{}^2}\right)^{.75}\right]$
	133	42	STO	
	134	04	04	
	135	43	RCL	$\rightarrow R_4$
	136	01	01	
	137	34	√x	
	138	65	×	
	139	93	.	
	140	00	0	
	141	00	0	
	142	05	5	
	143	06	6	
	144	05	5	
	145	55	÷	
	146	43	RCL	
	147	04	04	
	148	95	=	
	149	71	SBR	$\tanh\left[.00565\left(\frac{Fg}{U_A{}^2}\right)^{.5}\right]$
	150	30	TAN	
	151	65	×	$\frac{}{R_4}$
	152	43	RCL	
	153	04	04	
	154	65	×	
	155	93	.	
	156	02	2	
	157	08	8	
	158	03	3	
	159	55	÷	
	160	43	RCL	
	161	08	08	

STEP	KEY ENTRY	KEY CODE		COMMENTS
	162	95	=	
	163	69	OP *	PRINT H
R/S SEE BELOW →	164	06	06 *	
	165	03	3 *	"T" PRINT CODE
	166	07	7 *	
	167	69	OP *	
	168	04	04 *	
	169	43	RCL	
	170	00	00	
	171	45	Y^x	
	172	93	.	
	173	03	3	
	174	07	7	
	175	05	5	
	176	65	×	
	177	93	.	
	178	08	8	
	179	03	3	
	180	03	3	
	181	95	=	
	182	71	SBR	$\tanh\left[.833\left(\frac{dg}{U_A{}^2}\right)^{.375}\right]$
	183	30	TAN	
	184	42	STO	$\rightarrow R_4$
	185	04	04	
	186	43	RCL	
	187	01	01	
	188	45	Y^x	
	189	93	.	
	190	03	3	
	191	03	3	
	192	03	3	
	193	65	×	
	194	93	.	
	195	00	0	
	196	03	3	
	197	07	7	
	198	09	9	
	199	55	÷	
	200	43	RCL	
	201	04	04	
	202	95	=	
	203	71	SBR	$\tanh\left[.0379\left(\frac{Fg}{U_A{}^2}\right)^{.333}\right]$
	204	30	TAN	
	205	65	×	$\frac{}{R_4}$
	206	43	RCL	
	207	04	04	
	208	65	×	
	209	07	7	
	210	93	.	
	211	05	5	
	212	04	4	
	213	55	÷	
	214	43	RCL	
	215	08	08	

103A-4

* DELETE IF PRINTER IS UNAVAILABLE
R/S-INSERT IF PRINTER IS UNAVAILABLE

STEP	KEY ENTRY	KEY CODE		COMMENTS
	216	55	-	
	217	43	RCL	
	218	07	07	
	219	95	=	
	220	69	OP	*
R/S →	221	06	06	* PRINT T
	222	65	×	
	223	43	RCL	
	224	09	09	
	225	55	÷	
	226	02	2	*
	227	03	3	* "HRS" PRINT CODE
	228	03	3	*
	229	05	5	*
	230	03	3	*
	231	06	6	*
	232	69	OP	*
	233	04	04	*
	234	43	RCL	
	235	07	07	
	236	95	=	
	237	45	YX	
	238	53	(	
	239	07	7	
	240	55	÷	
	241	03	3	
	242	54	)	
	243	65	×	
	244	05	5	
	245	03	3	
	246	07	7	
	247	65	×	
	248	43	RCL	
	249	07	07	
	250	55	÷	
	251	43	RCL	$t = \frac{U_A}{g} 539 \left(\frac{T_0}{U_A}\right)^{3/3}$
	252	09	09	
	253	55	÷	
	254	03	3	CONVERT SECONDS
	255	06	6	TO HOURS
	256	00	0	
	257	00	0	
	258	95	=	
	259	69	OP	* PRINT MINIMUM
	260	06	06	* DURATION t
	261	98	ADV	*
	262	91	R/S	
	263	76	LBL	SUBROUTINE TO
	264	30	TAN	COMPUTE TANH(x)
	265	42	STO	
	266	02	02	
	267	22	INV	
	268	23	LNX	
	269	75	-	
	270	48	EXC	
	271	02	02	
	272	94	+/-	
	273	22	INV	
	274	23	LNX	
	275	42	STO	
	276	03	03	
	277	95	=	
	278	55	÷	
	279	53	(	
	280	43	RCL	
	281	02	02	
	282	85	+	
	283	43	RCL	
	284	03	03	
	285	95	=	
	286	92	RTN	

*- DELETE IF A PRINTER IS UNAVAILABLE

R/S - INSERT IF PRINTER IS UNAVAILABLE

103A-5

Program Description

Program Title	104R Depth-Limited Design Breaking Wave Height at Structure (RPN logic)
Name	T.L. Walton, Jr.
Date	10/80
Address	Coastal Engineering Research Center
City	Kingman Building Fort Belvoir, Virginia
Zip Code	22060

Program Description, Equations, Variables, etc.

This algorithm computes the depth-limited breaking wave height at a structure for design purposes. It can be used in lieu of Figure 7-4 of the Shore Protection Manual. The equation for the curves in Figure 7-4 is not given in the SPM but can be found by simultaneous solution of SPM equations (2-91), (2-92), (2-93), (7-3), and (7-4). Input is wave period, T, and water depth at the structure toe, d_s. The development of the equation is derived on the attached solution sheet. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I and II, Chs, 2 and 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

SOLUTION SHEET FOR PROGRAM 104R

The following equations are given in the Shore Protection Manual:

$$\frac{d_b}{H_b} = \frac{1}{b - (aH_b/gT^2)} \tag{2-91}$$

$$a = 43.75(1 - e^{-19m}) \tag{2-92}$$

$$b = \frac{1.56}{(1 + e^{-19.5m})} \tag{2-93}$$

$$x_p = \tau_p H_b = (4.0 - 9.25\ m)H_b \tag{7-3}$$

$$H_b = \frac{d_s}{\beta - m\tau_p} \tag{7-4}$$

Equation (7-4) can be rewritten in dimensionless form as:

$$\hat{H}_b = \frac{\hat{d}_s}{\left[(b - a\hat{H}_b)^{-1} - m\tau_p\right]}$$

where

$$\hat{H}_b = H_b/gT^2 \text{ and } \hat{d}_s = d_s/gT^2$$

The above equation can then be solved via the quadratic formula for $\hat{H}_b$ in terms of $\hat{d}_s$, τ_p, m, a, and b where the positive root provides useful results.

$$\hat{H}_b = \left\{(m\tau_p b - a\hat{d}_s - 1) + \left[(m\tau_p b - a\hat{d}_s - 1)^2 + 4am\tau_p\, b\hat{d}_s\right]^{1/2}\right\}.(2am\tau_p)^{-1}$$

This is the equation used in the program for design breaking wave height.

104R-2

User Instructions

Program Title: 104R Depth-Limited Design Breaking Wave Height at Structure

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	ENTER BOTTOM SLOPE m (TANGENT)	m	A	m
2	ENTER DEPTH AT STRUCTURE			
	ds (FEET OR METERS)	ds	B	ds
3	ENTER WAVE PERIOD T (SEC)			
	PRESS E FOR ENGLISH UNITS	T(FT)	E	
	PRESS fe FOR METRIC UNITS	T(M)	f e	
4	READ Hb IN DISPLAY			Hb(FT or M)
5	FOR NEW T GO TO STEP 3			
	NOTE: WITH PRINTER, m, ds, T, Hb ARE PRINTED AND LABELED			
	EXAMPLE:			
	ds = 10 FT, T = 10 SEC, m = 0.10			
	ENTER m = 0.10, PRESS A	0.10	A	0.10
	ENTER ds = 10 FT, PRESS B	10 FT	B	10.00
	ENTER T = 10 SEC, PRESS E	10 SEC	E	
	READ Hb = 17.98 IN DISPLAY			17.98

104R-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	
	STO 0	33 00	$m \rightarrow R_0$
	R/S	84	
	f LBL B	31 25 12	
	STO 7	33 07	$d_s \rightarrow R_7$
	R/S	84	
	g LBL e	32 25 15	
	STO 9	33 09	$T \rightarrow R_9$
	9	09	
010	.	83	
	8	08	
	1	01	
	STO B	33 08	g(METRIC) $\rightarrow R_B$
	GTO f d	22 31 14	
	f LBL E	31 25 15	
	STO 9	33 09	$T \rightarrow R_9$
	3	03	
	2	02	
	.	83	
020	2	02	
	STO 8	33 08	g(ENGLISH) $\rightarrow R_B$
	g LBL f d	32 25 14	
	RCL 7	34 07	
	RCL B	34 08	
	÷	81	
	RCL 9	34 09	
	g X^2	32 54	
	÷	81	
	STO 1	33 01	$\frac{d_s}{gT^2} \rightarrow R_1$
030	RCL 0	34 00	
	1	01	
	9	09	
	X	71	
	CHS	42	
	g e^x	32 52	
	CHS	42	
	1	01	
	+	61	
	4	04	
040	3	03	
	.	85	
	7	07	
	5	05	
	X	71	
	STO 3	33 03	$43.75(1-e^{-19m}) = a \rightarrow R_3$
	RCL 0	34 00	
	1	01	
	9	09	
	.	83	
050	5	05	
	X	71	
	CHS	42	
	g e^x	32 52	
	1	01	
	+	61	
	1	01	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	.	83	
	5	05	
	6	06	
060	÷	81	
	h $\sqrt{x}$	35 62	
	STO A	33 04	
	RCL 0	34 00	
	ENTER	41	
	9	09	
	.	83	
	2	02	
	5	05	
	X	71	
070	4	04	
	−	51	
	CHS	42	
	RCL 0	34 00	
	X	71	
	STO 5	33 05	$m\tau_p = m(4-9.25m) \rightarrow R_5$
	RCL 4	34 04	
	X	71	
	1	01	
	−	51	
080	RCL 1	34 01	
	RCL 3	34 03	
	X	71	
	−	51	
	STO 6	33 06	$m\tau_p b - a\hat{d}_s - 1 \rightarrow R_6$
	g X^2	32 54	
	4	04	
	RCL 3	34 03	
	X	71	
	RCL 4	34 04	
090	X	71	
	RCL 5	34 05	
	X	71	
	RCL 1	34 01	
	X	71	
	+	61	
	f $\sqrt{x}$	31 54	$((R_6)^2 + 4am\tau_p)^{1/2}$
	RCL 6	34 06	
	+	61	
	2	02	
100	÷	81	
	RCL 3	34 03	
	÷	81	
	RCL 5	34 05	
	÷	81	$\hat{H}_b = \frac{H_b}{gT^2}$
	RCL 1	34 01	
	÷	81	
	RCL 7	34 07	
	X	71	
	R/S	84	H_b IN DISPLAY
110			

104R-4

Program Description

Program Title	104A Depth-Limited Design Breaking Wave Height at Structure (AOS logic)
Name	W.A. Birkemeier
Date	5/81
Address	CERC Field Research Facility
City	Kitty Hawk,
State	North Carolina
Zip Code	27949

Program Description, Equations, Variables, etc.

This algorithm computes the depth-limited breaking wave height at a structure for design purposes. It can be used in lieu of Figure 7-4 of the Shore Protection Manual. The equation for the curves in Figure 7-4 is not given in the SPM but can be found by simultaneous solution of SPM equations (2-91), (2-92), (2-93), (7-3), and (7-4). Input is wave period, T, and water depth at the structure toe, d_s. The development of the equation is derived on the solution sheet included with program 104R. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I and II, Chs. 2 and 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

User Instructions

Program Title: 104A Depth-Limited Design Breaking Wave Height at structure

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	ENTER BOTTOM SLOPE m(tangent)	m	A	M
2	ENTER depth AT STRUCTURE ds(ft OR METERS)	ds	B	ds
3	ENTER WAVE PERIOD T (SEC)			
	PRESS E FOR ENGLISH UNITS	for(ft)	E	
	PRESS E' FOR METRIC UNITS	for(m)	E'	
4	READ H_b IN DISPLAY			Hb(ft)
5	FOR NEW T GO TO STEP 3			OR
	NOTE: WITH PRINTER m, ds, T, Hb ARE			Hb(M)
	PRINTED AND LABELED			
	EXAMPLE: ds = 10ft, T = 10SEC, m = 0.10			
1	ENTER m = 0.1 PRESS A	0.10	A	0.10
2	ENTER ds = 10 ft PRESS B	10 ft	B	10
3	ENTER T = 10 SEC PRESS E	10 SEC	E	
4	READ H_b = 17.98 IN DISPLAY			17.98
	PRINTOUT FROM EXAMPLE			
	0.1 M			
	10. DS			
	10. T			
	17.98182955 HB			

104A-2

Program Listing

STEP	KEY ENTRY	KEY CODE		COMMENTS
000	76	LBL		
001	11	A		
002	42	STO		$m \rightarrow R_0$
003	00	00		
004	03	3	*	"M" PRINT CODE
005	00	0	*	
006	69	OP	*	
007	04	04	*	
008	43	RCL	*	
009	00	00	*	
010	69	OP	*	PRINT BOTTOM
011	06	06	*	SLOPE M
012	91	R/S		
013	76	LBL		
014	12	B		
015	42	STO		$d_s \rightarrow R_7$
016	07	07		
017	01	1	*	"DS" PRINT CODE
018	06	6	*	
019	03	3	*	
020	06	6	*	
021	69	OP	*	
022	04	04	*	
023	43	RCL	*	
024	07	07	*	
025	69	OP	*	PRINT d_s
026	06	06	*	
027	91	R/S		
028	76	LBL		E' ALLOWS METRIC
029	10	E'		DATA ENTRY
030	42	STO		$T \rightarrow R_9$
031	09	09		
032	09	9		
033	93	.		$g = 9.81$
034	08	8		
035	01	1		
036	42	STO		$g \rightarrow R_8$
037	08	08		
038	03	3	*	
039	00	0	*	
040	69	OP	*	
041	04	04	*	
042	69	OP	*	PRINT "M" TO
043	05	05	*	INDICATE METRIC
044	19	D'		
045	76	LBL		
046	15	E		E - ALLOWS ENGLISH
047	42	STO		DATA ENTRY
048	09	09		$T \rightarrow R_9$
049	03	3		
050	02	2		$g = 32.2$ ft/sec^2
051	93	.		
052	02	2		
053	42	STO		$g \rightarrow R_8$

STEP	KEY ENTRY	KEY CODE		COMMENTS
054	08	08		
055	76	LBL		
056	19	D'		
057	03	3	*	"T" PRINT CODE
058	07	7	*	
059	69	OP	*	
060	04	04	*	
061	43	RCL	*	
062	09	09	*	
063	69	OP	*	PRINT T
064	06	06	*	
065	43	RCL		
066	07	07		
067	55	÷		
068	43	RCL		
069	08	08		
070	55	÷		
071	43	RCL		
072	09	09		
073	33	X^2		
074	95	=		
075	42	STO		$\frac{d_s}{gT^2} \rightarrow R_1$
076	01	01		
077	43	RCL		
078	00	00		
079	65	×		
080	01	1		
081	09	9		
082	95	=		
083	94	+/-		
084	22	INV		
085	23	LNX		
086	94	+/-		
087	85	+		
088	01	1		
089	95	=		
090	65	×		
091	04	4		
092	03	3		
093	93	.		
094	07	7		
095	05	5		$43.75(1-e^{-9m})$
096	95	=		
097	42	STO		$\rightarrow R_3$
098	03	03		
099	43	RCL		
100	00	00		
101	65	×		
102	01	1		
103	09	9		
104	93	.		
105	05	5		
106	95	=		
107	94	+/-		

104A-3

*-DELETE IF PRINTER IS NOT AVAILABLE

STEP	KEY ENTRY	KEY CODE	COMMENTS
108	22	INV	
109	23	LNX	
110	85	+	
111	01	1	
112	95	=	
113	55	-	
114	01	1	
115	93	.	
116	05	5	
117	06	6	
118	95	=	$\frac{1.56}{(1+e^{-19.5m})} = b$
119	35	1/X	
120	42	STO	
121	04	04	$\rightarrow R_4$
122	04	4	
123	75	-	
124	43	RCL	
125	00	00	
126	65	×	
127	09	9	
128	93	.	
129	02	2	
130	05	5	
131	95	=	
132	65	×	
133	43	RCL	
134	00	00	
135	95	=	$m\gamma_p = (4-9.25m)m$
136	42	STO	
137	05	05	$\rightarrow R_5$
138	65	×	
139	43	RCL	
140	04	04	
141	75	-	
142	43	RCL	
143	03	03	
144	65	×	
145	43	RCL	
146	01	01	
147	75	-	
148	01	1	
149	95	=	$m\gamma_p b - a\hat{d}_s - 1$
150	42	STO	
151	06	06	$\rightarrow R_6$
152	33	X^2	
153	85	+	
154	04	4	
155	65	×	
156	43	RCL	
157	03	03	
158	65	×	
159	43	RCL	
160	04	04	
161	65	×	

STEP	KEY ENTRY	KEY CODE		COMMENTS
162	43	RCL		
163	05	05		
164	65	×		
165	43	RCL		$4am\gamma_p b\hat{d}_s$
166	01	01		
167	95	=		
168	34	$\sqrt{X}$		
169	85	+		
170	43	RCL		$((R_6)^2 + 4am\gamma_p)^{1/2}$
171	06	06		
172	95	=		
173	55	÷		
174	53	(		
175	02	2		
176	65	×		
177	43	RCL		
178	03	03		
179	65	×		
180	43	RCL		
181	05	05		$\hat{H}_b = \frac{H_b}{gT^2}$
182	95	=		
183	55	÷		
184	43	RCL		
185	01	01		
186	65	×		
187	02	2	*	
188	03	3	*	"HB" PRINT CODE
189	01	1	*	
190	04	4	*	
191	69	OP	*	
192	04	04	*	
193	43	RCL		
194	07	07		
195	95	=		H_b
196	69	OP	*	
197	06	06	*	PRINT H_b
198	98	ADV	*	
199	91	R/S		

104A-4

* - DELETE IF PRINTER IS NOT AVAILABLE

Program Description

Program Title	105R Wave Transmission - Fuchs' Equation (RPN logic)
Name	T.L. Walton, Jr.
Date	10/80
Address	Coastal Engineering Research Center
City	Kingman Building
State	Fort Belvoir, Virginia
Zip Code	22060

Program Description, Equations, Variables, etc.

This algorithm computes wavelength, L, in water depth, d, given the wave period, T. The program then computes wave transmission over a thin vertical barrier in water depth, d, using Fuchs' equation:

$$\frac{H_t}{H_i} = \sqrt{1 - \frac{\frac{4\pi h}{L} + \sinh\frac{4\pi h}{L}}{\frac{4\pi d}{L} + \sinh\frac{4\pi d}{L}}}$$

where H_t is the transmitted wave height, H_i the incident wave height, and h the height of barrier. Note that this equation *cannot* be used when wave transmission is by overtopping of a structure. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. II, Ch. 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, p. 7-62.

Operating Limits and Warnings

User Instructions

Program Title: 105R Wave Transmission - Fuchs' Equation

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	ENTER WATER DEPTH d IN FEET OR	d (FT) OR		
	METERS, READ 2πd IN DISPLAY	d (M)	A	2πd
2	ENTER SILL HEIGHT h IN FEET	h (FT) OR		
	OR METERS	h (M)	B	
3	ENTER WAVE PERIOD T (SECONDS)	T (SEC)		
4	PRESS E FOR ENGLISH UNITS		E	
	PRESS f e FOR METRIC UNITS		f e	
5	READ L (IN FEET OR METERS)			L
6	PRESS R/S		R/S	
7	READ H_T/H_i			H_T/H_i
8	TO REPEAT FOR NEW T GO TO			
	STEP 3			
	EXAMPLE :			
	d = 15 FT, h = 10 FT., T = 10 SEC			
	ENTER d = 15, PRESS A	15 FT	A	
	ENTER h = 10, PRESS B	10 FT	B	
	ENTER T = 10, PRESS E	10 SEC	E	
	READ L = 213.02 FT.			213.02
	PRESS R/S, READ H_T/H_i = 0.60		R/S	0.60

105R-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	ENTER d
	ENTER	41	
	2	02	
	X	71	
	h π	35 73	
	X	71	
	STO 0	33 00	2πd → R0
	R/S	84	
	f LBL B	31 25 12	ENTER h
010	STO 8	33 08	
	R/S	84	
	g LBL e	32 25 15	
	STO 7	33 07	T → R7
	9	09	
	.	83	
	8	08	
	1	01	
	STO 6	33 06	g(METRIC) → R6
	GTO f b	22 31 12	
020	f LBL E	31 25 15	
	STO 7	33 07	T → R7
	3	03	
	2	02	
	.	83	
	2	02	
	STO 6	33 06	g(ENGLISH) → R6
	g LBL f b	32 25 12	
	RCL 7	34 07	
	g x^2	32 54	
030	RCL 6	34 06	
	X	71	
	2	02	
	÷	81	
	h π	35 73	
	÷	81	
	STO 1	33 01	L_O → R1
	g LBL d	32 25 14	
	STO 3	33 03	L_{OLD} → R3
	h 1/x	35 62	
040	RCL 0	34 00	
	X	71	
	STO 4	34 04	$\frac{2\pi d}{L_{OLD}}$ → R4
	g e^x	32 52	
	RCL 4	34 04	
	CHS	42	
	g e^x	32 52	
	−	51	
	RCL 4	34 04	
	g e^x	32 52	
050	RCL 4	34 04	
	CHS	42	
	g e^x	32 52	
	+	61	
	÷	81	tanh $\frac{2\pi d}{L_{OLD}}$
	RCL 1	34 01	
	X	71	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	RCL 3	34 03	
	+	61	
	2	02	
060	÷	81	
	STO 2	33 02	L_{NEW} → R2
	RCL 3	34 03	
	−	51	
	h ABS	35 69	
	1	01	
	g x>y	32 81	
	GTO f c	22 31 13	
	RCL 2	34 02	
	GTO f d	22 31 14	
070	g LBL f c	32 25 13	
	RCL 2	34 02	
	R/S	84	L IN DISPLAY
	h 1/x	35 62	
	RCL 0	34 00	
	X	71	
	2	02	
	X	71	$\frac{4\pi d}{L}$ → R6
	STO 6	33 06	
	f GSB 1	31 22 01	
080	RCL 6	34 06	
	+	61	
	STO 7	33 07	R6 + SINH (R6) → R7
	4	04	
	ENTER	41	
	h π	35 73	
	X	71	
	RCL 8	34 08	
	X	71	
	RCL 2	34 02	
090	÷	81	$\frac{4\pi h}{L}$ → R9
	STO 9	33 09	
	f GSB 1	31 22 01	
	RCL 9	34 09	
	+	61	
	RCL 7	34 07	
	÷	81	
	CHS	42	
	1	01	
	+	61	
100	f $\sqrt{x}$	31 54	
	R/S	84	Ht/Hi IN DISPLAY
	f LBL 1	31 25 01	SINH SUBROUTINE
	STO 5	33 05	
	g e^x	32 52	
	RCL 5	34 05	
	CHS	42	
	g e^x	32 52	
	−	51	
	2	02	
110	÷	81	
	h RTN	35 22	

105R-3

Program Description

Program Title	105A Wave Transmission - Fuchs' Equation (AOS logic)
Name	W.A. Birkemeier **Date** 5/81
Address	CERC Field Research Facility
City	Kitty Hawk, **State** North Carolina **Zip Code** 27949

Program Description, Equations, Variables, etc.

This algorithm computes wavelength, L, in water depth, d, given the wave period, T. The program then computes wave transmission over a thin vertical barrier in water depth, d, using Fuchs' equation:

$$\frac{H_t}{H_i} = \sqrt{1 - \frac{\frac{4\pi d}{L} + \sinh\frac{4\pi d}{L}}{\frac{4\pi d}{L} + \sinh\frac{4\pi d}{L}}}$$

where H_t is the transmitted wave height, H_i the incident wave height, and h the height of barrier. Note that this equation *cannot* be used when wave transmission is by overtopping of a structure. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. II, Ch. 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, p. 7-62.

Operating Limits and Warnings

User Instructions

Program Title: 105A Wave Transmission - Fuchs' Equation

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	ENTER WATER DEPTH (d) IN FEET OR METERS	d(ft) OR		
		d(m)	A	d
2	ENTER SILL HEIGHT (h) IN FEET OR METERS	h(ft) OR		
	(WITH PRINTER, LABEL READS SH FOR SILL HEIGHT)	h(m)	B	h
3	ENTER WAVE PERIOD T (SEC)			
	PRESS E FOR ENGLISH UNITS	T(SEC)	E	
	PRESS E' FOR METRIC UNITS	T(SEC)	E'	
4	WITH PRINTER Lo, L, Ht/Hi ARE PRINTED			Lo
	AND LABELED, Lo AND L ARE COMPUTED IN			L
	INPUT UNITS. WITHOUT PRINTER:			Ht/Hi
	READ Lo			Lo
	PRESS R/S READ L		R/S	L
	PRESS R/S READ Ht/Hi		R/S	Ht/Hi
5	TO REPEAT FOR NEW T GO TO STEP 3			
	EXAMPLE			
	d = 15 ft , h = 10ft , T = 10 SEC			
	ENTER d = 15 PRESS A	15 ft	A	15
	ENTER h = 10 PRESS B	10 ft	B	10
	ENTER T = 10 PRESS E	10 SEC	E	10
	READ Lo = 512.48			512.48
	PRESS R/S (IF REQUIRED) READ L = 213.02			213.02
	PRESS R/S (IF REQUIRED) READ Ht/Hi			0.598
	PRINTOUT OF EXAMPLE			
	15. D			
	10. SH			
	10. T			
	512.4789168 LO			
	213.0238318 L			
	0.597721319 H/H			

105A-2

Program Listing

STEP	KEY ENTRY	KEY CODE		COMMENTS
000	76	LBL		
001	11	A		
002	42	STO		d→R0
003	00	00		
004	65	×		
005	01	1	*	
006	06	6	*	"D" PRINT CODE
007	69	OP	*	
008	04	04	*	
009	02	2		
010	65	×		
011	89	π		
012	95	=		
013	48	EXC		2πd→R0
014	00	00		
015	69	OP	*	PRINT d
016	06	06	*	
017	91	R/S		
018	76	LBL		
019	12	B		
020	42	STO		h→R8
021	08	08		
022	03	3	*	
023	06	6	*	"SH" PRINT CODE
024	02	2	*	(SILL HEIGHT)
025	03	3	*	
026	69	OP	*	
027	04	04	*	
028	43	RCL	*	
029	08	08	*	
030	69	OP	*	
031	06	06	*	PRINT h
032	91	R/S		
033	76	LBL		STEPS 33 TO 49
034	10	E'		ALLOW METRIC
035	42	STO		INPUT/OUTPUT
036	07	07		T→R7
037	09	9		
038	93	.		g= 9.81
039	08	8		
040	01	1		
041	42	STO		g→R6
042	06	06		
043	03	3	*	"M" PRINT CODE
044	00	0	*	
045	69	OP	*	PRINT "M" TO
046	04	04	*	INDICATE METRIC
047	69	OP	*	
048	05	05	*	
049	17	B'		
050	76	LBL		STEPS 50 TO 59
051	15	E		ALLOW ENGLISH
052	42	STO		INPUT/OUTPUT
053	07	07		T→R7
054	03	3		
055	02	2		
056	93	.		
057	02	2		
058	42	STO		g→R6
059	06	06		
060	76	LBL		
061	17	B'		
062	03	3	*	"T" PRINT CODE
063	07	7	*	
064	69	OP	*	
065	04	04	*	
066	43	RCL		
067	07	07		
068	69	OP	*	PRINT T
069	06	06	*	
070	33	X²		
071	65	×		
072	43	RCL		
073	06	06		
074	55	÷		
075	02	2		
076	55	÷		
077	02	2	*	"Lo" PRINT CODE
078	07	7	*	
079	03	3	*	
080	02	2	*	
081	69	OP	*	
082	04	04	*	
083	89	π		
084	95	=		
085	42	STO		Lo→R1
086	01	01		
087	69	OP	*	PRINT Lo
R/S → 088	06	06	*	
089	76	LBL		
090	14	D		
091	01	1		
092	32	X:T		
093	43	RCL		
094	01	01		
095	76	LBL		
096	19	D'		
097	42	STO		L_{OLD}→R3
098	03	03		
099	35	1/X		
100	65	×		
101	43	RCL		
102	00	00		
103	95	=		
104	42	STO		$\frac{2\pi d}{L_{OLD}}$→R4
105	04	04		
106	22	INV		
107	23	LNX		
108	75	-		
109	48	EXC		

*- DELETE IF PRINTER IS NOT AVAILABLE
R/S- INSERT IF PRINTER IS NOT AVAILABLE

105A-3

STEP	KEY ENTRY	KEY CODE	COMMENTS
	110	04 04	
	111	24 +/-	
	112	22 INV	
	113	23 LNX	
	114	42 STO	
	115	05 05	
	116	95 =	
	117	55 ÷	
	118	53 (	
	119	43 RCL	
	120	04 04	
	121	85 +	
	122	43 RCL	
	123	05 05	
	124	95 =	tanh 2πd/L old
	125	65 ×	
	126	43 RCL	
	127	01 01	
	128	85 +	
	129	43 RCL	
	130	03 03	
	131	95 =	
	132	55 ÷	
	133	02 2	
	134	95 =	
	135	42 STO	$L_{NEW} \rightarrow R_2$
	136	02 02	
	137	75 -	
	138	43 RCL	$L_{NEW} - L_{OLD}$
	139	03 03	
	140	95 =	
	141	50 I×I	
	142	22 INV	
	143	77 GE	ITERATE TO COMPUTE L
	144	18 C'	
	145	43 RCL	
	146	02 02	
	147	19 D'	
	148	76 LBL	
	149	18 C'	
	150	02 2 *	"L" PRINT CODE
	151	07 7 *	
	152	69 OP *	
	153	04 04 *	
	154	43 RCL	
	155	02 02	
	156	69 OP *	PRINT L
	157	06 06 *	
R/S →	158	35 1/X	
	159	65 ×	
	160	43 RCL	
	161	00 00	
	162	65 ×	
	163	02 2	
	164	95 =	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	165	42 STO	$4\pi d/L \rightarrow R_6$
	166	06 06	
	167	71 SBR	
	168	38 SIN	$\sinh\left(\frac{4\pi d}{L}\right)$
	169	85 +	
	170	43 RCL	
	171	06 06	
	172	95 =	
	173	42 STO	$4\pi d/L + \sinh\left(\frac{4\pi d}{L}\right)$
	174	07 07	
	175	04 4	$\rightarrow R_7$
	176	65 ×	
	177	89 π	
	178	65 ×	
	179	43 RCL	
	180	08 08	
	181	55 ÷	
	182	43 RCL	
	183	02 02	
	184	95 =	
	185	42 STO	$4\pi h/L \rightarrow R_9$
	186	09 09	
	187	71 SBR	
	188	38 SIN	$\sinh\left(\frac{4\pi h}{L}\right)$
	189	85 +	
	190	43 RCL	$\frac{4\pi h}{L} + \sinh\left(\frac{4\pi h}{L}\right)$
	191	09 09	
	192	95 =	
	193	55 ÷	
	194	43 RCL	
	195	07 07	
	196	95 =	
	197	94 +/-	
	198	85 +	
	199	02 2 *	
	200	03 3 *	"H/H" PRINT CODE
	201	06 6 *	
	202	03 3 *	
	203	02 2 *	
	204	03 3 *	
	205	69 OP *	
	206	04 04 *	
	207	01 1	
	208	95 =	
	209	34 FX	
	210	69 OP *	
	211	06 06 *	PRINT H_t/H_i
	212	98 ADV *	
	213	91 R/S	
	214	76 LBL	STEPS 214 TO 235 COMPUTE $\sinh(R_{11})$
	215	38 SIN	
	216	42 STO	
	217	11 11	
	218	22 INV	
	219	23 LNX	

105A-4

STEP	KEY ENTRY	KEY CODE	COMMENTS
	220	48 EXC	
	221	11 11	
	222	94 +/-	
	223	22 INV	
	224	23 LNX	
	225	94 +/-	
	226	85 +	
	227	43 RCL	
	228	11 11	
	229	95 =	
	230	55 ÷	
	231	02 2	
	232	95 =	
	233	92 RTN	
130			
140			
150			
160			

STEP	KEY ENTRY	KEY CODE	COMMENTS
170			
180			
190			
200			
210			
220			

105A-5

APPENDIX

BLANK PROGRAM FORMS

Program Description

Program Title		
Name		**Date**
Address		
City	State	Zip Code

Program Description, Equations, Variables, etc.

Operating Limits and Warnings

User Instructions

Program Title

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001			
010			
020			
030			
040			
050			

STEP	KEY ENTRY	KEY CODE	COMMENTS
060			
070			
080			
090			
100			
110			

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
				170			
120							
				180			
130							
				190			
140							
				200			
150							
				210			
160							
				220			

Walton, Todd L. (Todd Leon)
Hand-held calculator algorithms for coastal engineering / by Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel.-- Fort Belvoir, Va. : U.S. Army Coastal Engineering Research Center ; Springfield, Va. : available from NTIS, 1982.
[71] p. : forms ; 28 cm.--(Coastal engineering technical aid ; no. 82-1). Cover title.
"January 1982."
Report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included with different versions for use with hand-held calculators which employ either the Reverse Polish Notation (RPN) or the Algebraic Operating System (AOS).
1. Coastal engineering--Data processing. 2. Calculating-machines. 3. Algorithms. 4. Wave transformation--Data processing. 5. Wave generation--Data processing. I. Birkemeier, William A. II. Weggel, J. Richard (John Richard), 1941. III. Title. IV. Series.
TC203 .U581ta no. 82-1 627

Walton, Todd L. (Todd Leon)
Hand-held calculator algorithms for coastal engineering / by Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel.-- Fort Belvoir, Va. : U.S. Army Coastal Engineering Research Center ; Springfield, Va. : available from NTIS, 1982.
[71] p. : forms ; 28 cm.--(Coastal engineering technical aid ; no. 82-1). Cover title.
"January 1982."
Report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included with different versions for use with hand-held calculators which employ either the Reverse Polish Notation (RPN) or the Algebraic Operating System (AOS).
1. Coastal engineering--Data processing. 2. Calculating-machines. 3. Algorithms. 4. Wave transformation--Data processing. 5. Wave generation--Data processing. I. Birkemeier, William A. II. Weggel, J. Richard (John Richard), 1941. III. Title. IV. Series.
TC203 .U581ta no. 82-1 627

Walton, Todd L. (Todd Leon)
Hand-held calculator algorithms for coastal engineering / by Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel.-- Fort Belvoir, Va. : U.S. Army Coastal Engineering Research Center ; Springfield, Va. : available from NTIS, 1982.
[71] p. : forms ; 28 cm.--(Coastal engineering technical aid ; no. 82-1). Cover title.
"January 1982."
Report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included with different versions for use with hand-held calculators which employ either the Reverse Polish Notation (RPN) or the Algebraic Operating System (AOS).
1. Coastal engineering--Data processing. 2. Calculating-machines. 3. Algorithms. 4. Wave transformation--Data processing. 5. Wave generation--Data processing. I. Birkemeier, William A. II. Weggel, J. Richard (John Richard), 1941. III. Title. IV. Series.
TC203 .U581ta no. 82-1 627

Walton, Todd L. (Todd Leon)
Hand-held calculator algorithms for coastal engineering / by Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel.-- Fort Belvoir, Va. : U.S. Army Coastal Engineering Research Center ; Springfield, Va. : available from NTIS, 1982.
[71] p. : forms ; 28 cm.--(Coastal engineering technical aid ; no. 82-1). Cover title.
"January 1982."
Report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included with different versions for use with hand-held calculators which employ either the Reverse Polish Notation (RPN) or the Algebraic Operating System (AOS).
1. Coastal engineering--Data processing. 2. Calculating-machines. 3. Algorithms. 4. Wave transformation--Data processing. 5. Wave generation--Data processing. I. Birkemeier, William A. II. Weggel, J. Richard (John Richard), 1941. III. Title. IV. Series.
TC203 .U581ta no. 82-1 627